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LABORATORY PRACTICE

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VOL. 9 No. 7 Published Monthly JULY 1960

GENERAL PURPOSE

REFRIGERATOR CENTRIFUGES

"MEDIUM" *Refrigerator*
250 ml. maximum container size.
1 litre total capacity.

"MAGNUM" *Refrigerator*
600 ml. maximum container size.
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Capacity as Mobile Model but for use with existing refrigeration.

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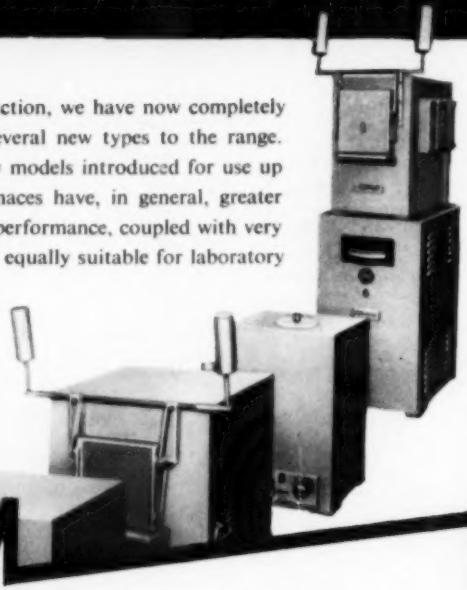

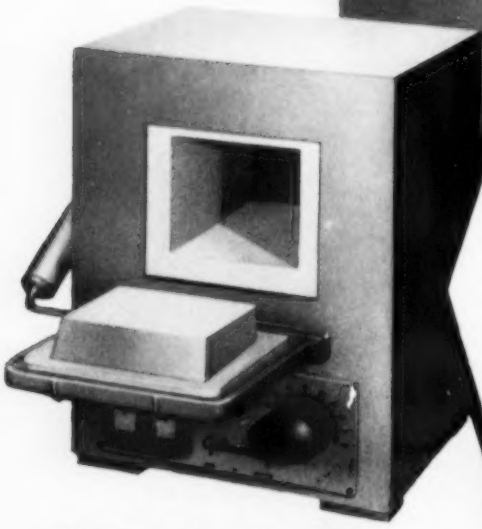

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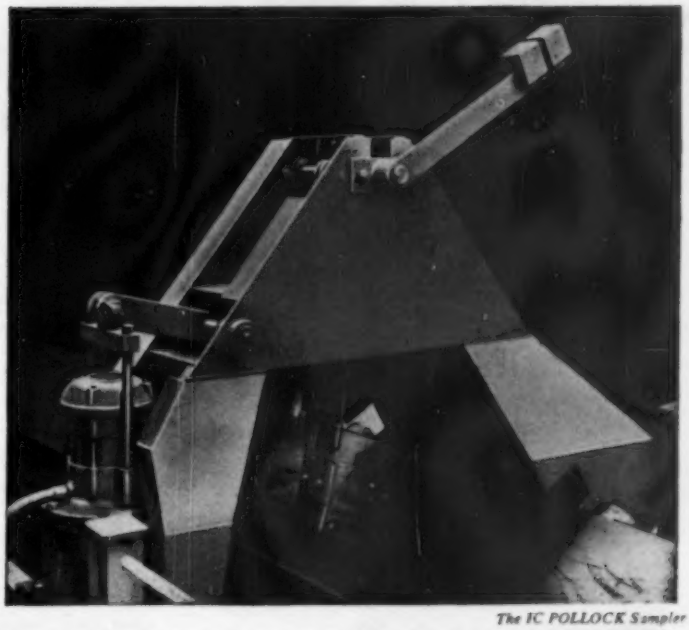

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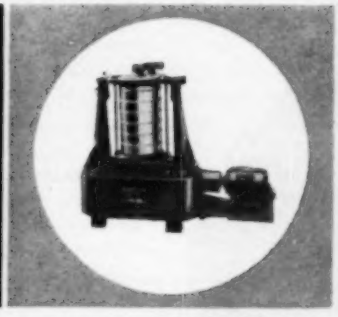

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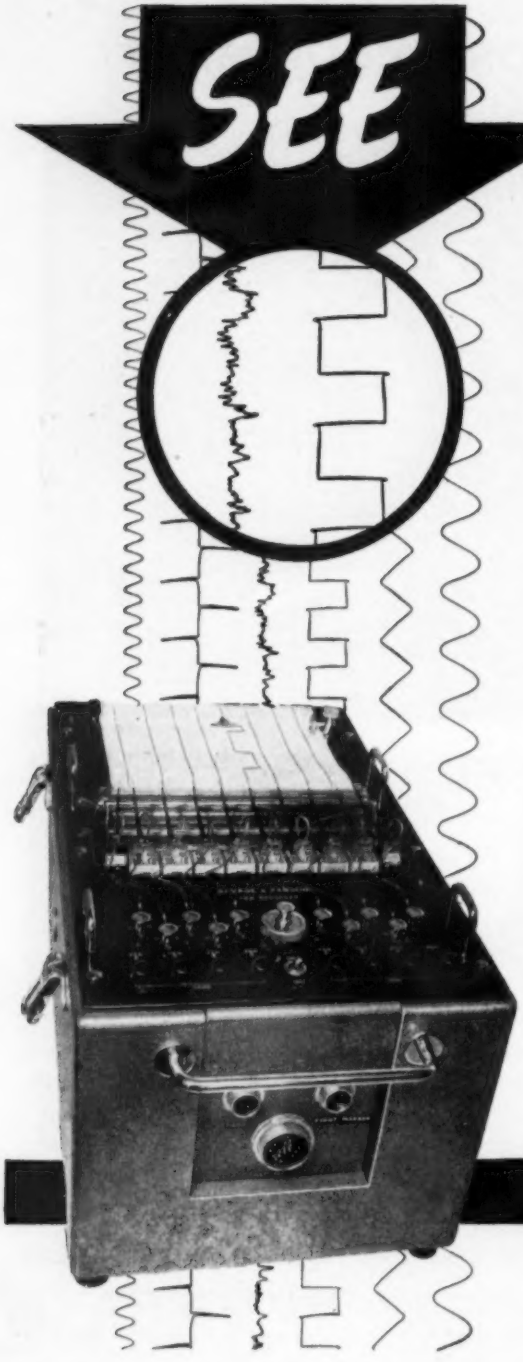

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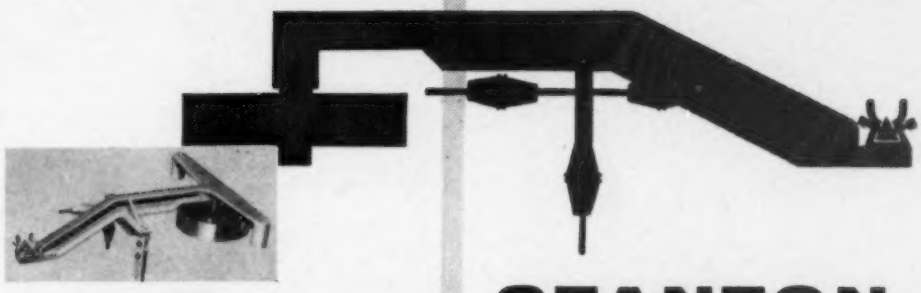

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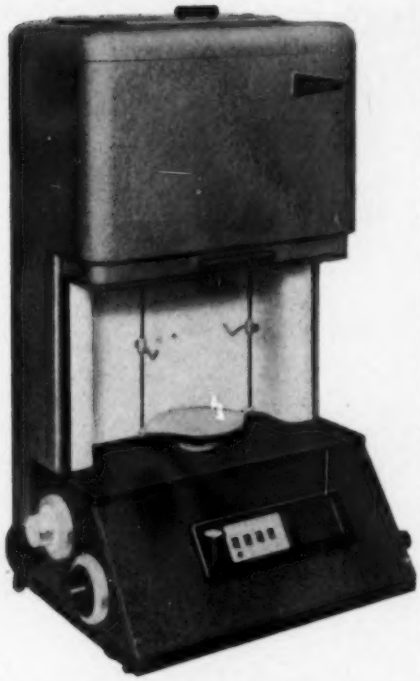

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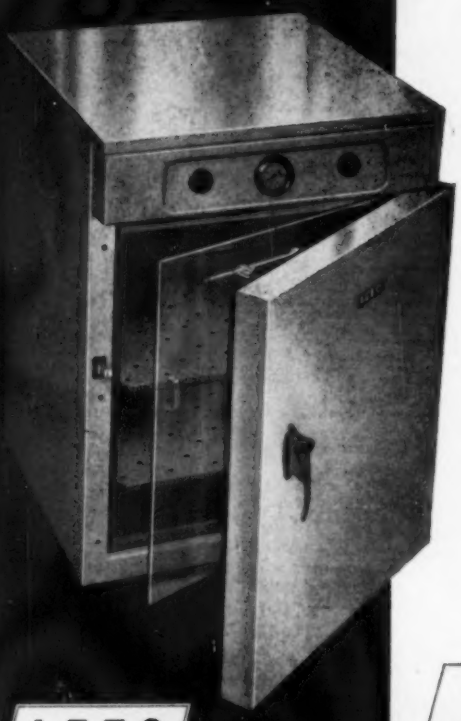

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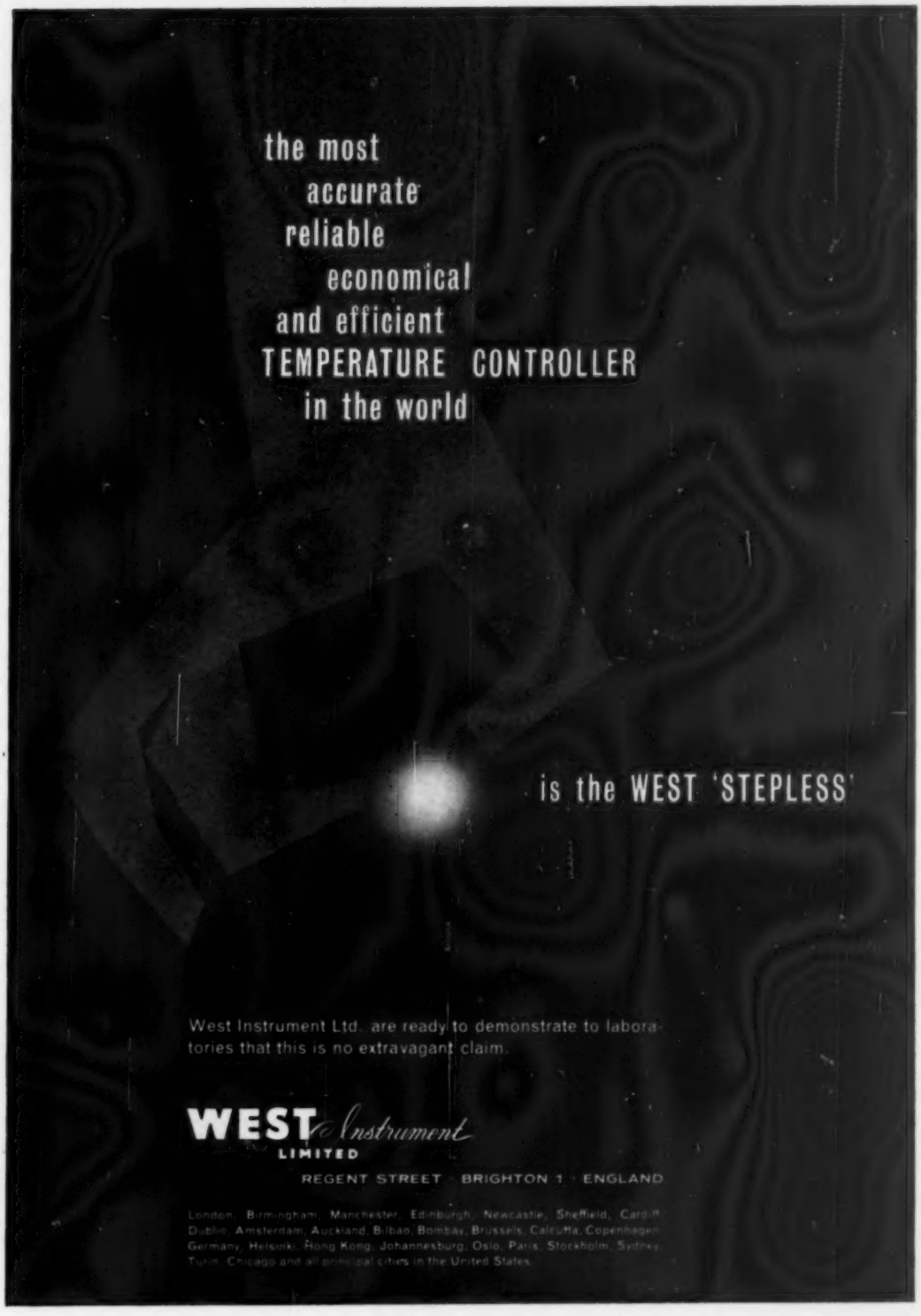
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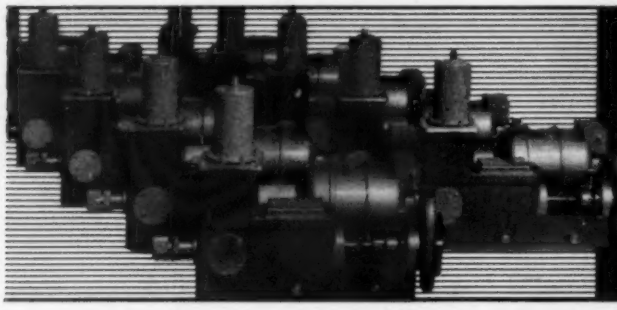

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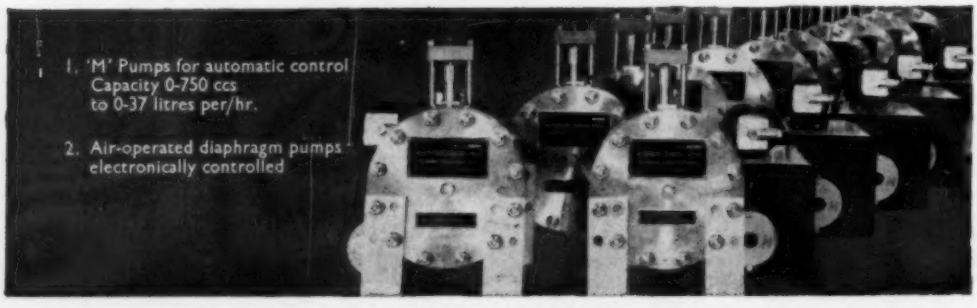

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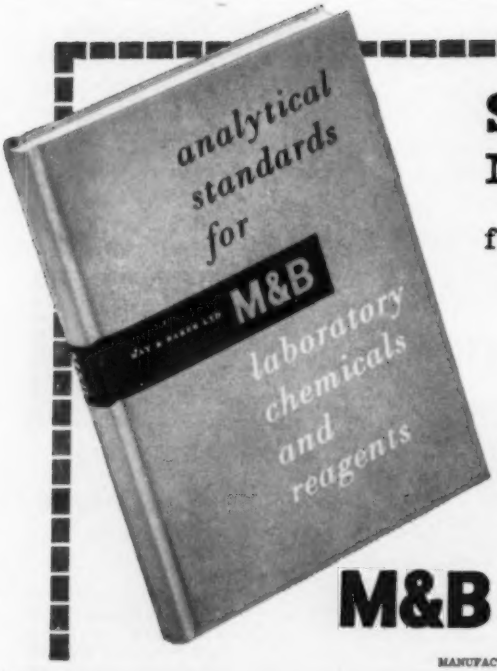

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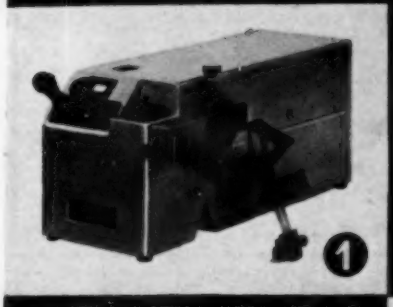

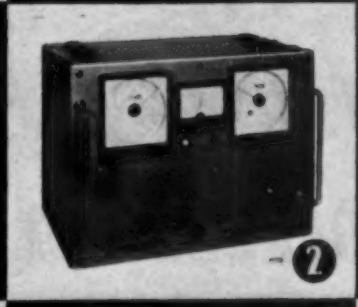

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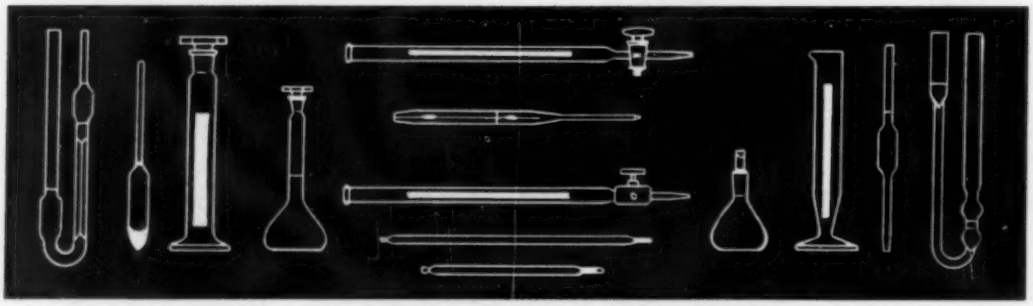

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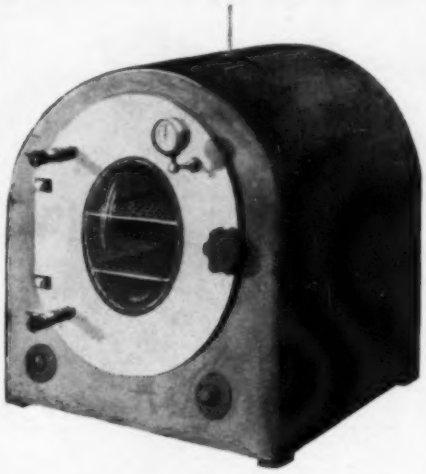

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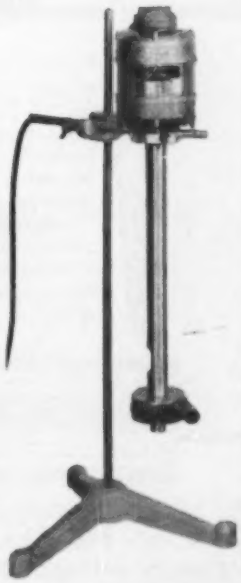

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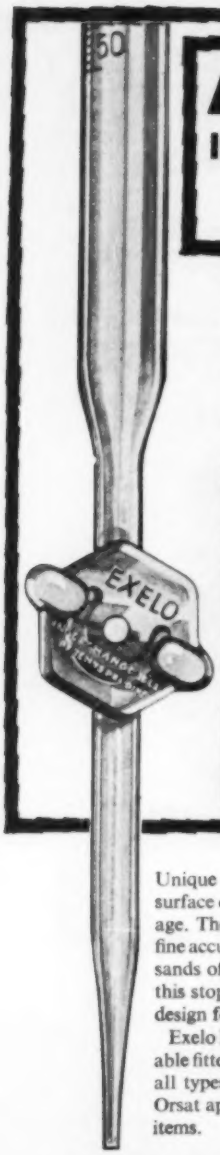

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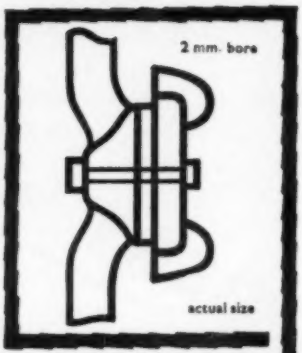

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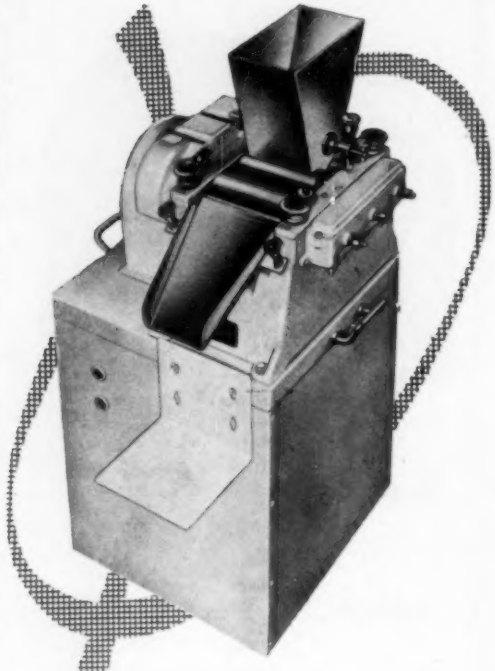

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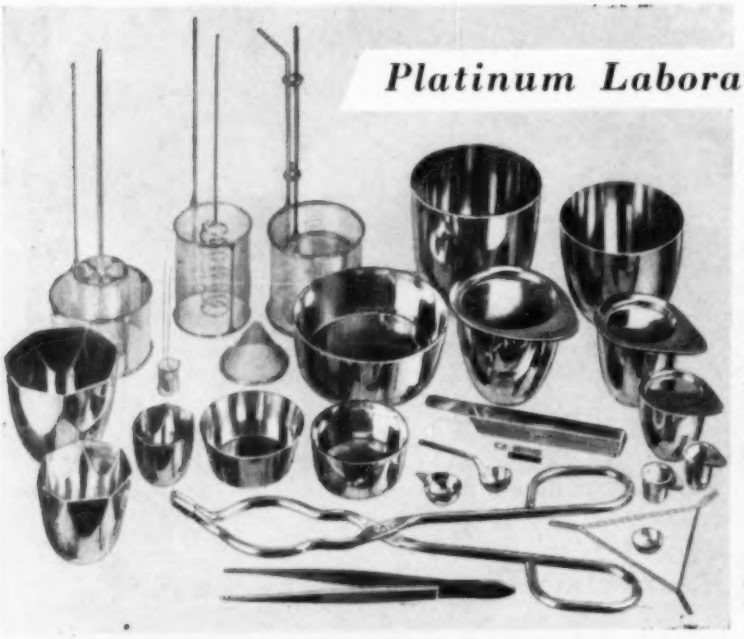

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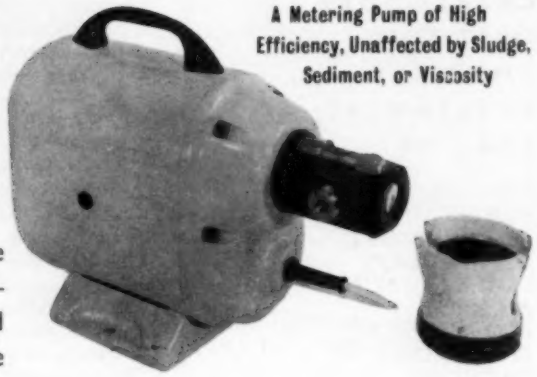

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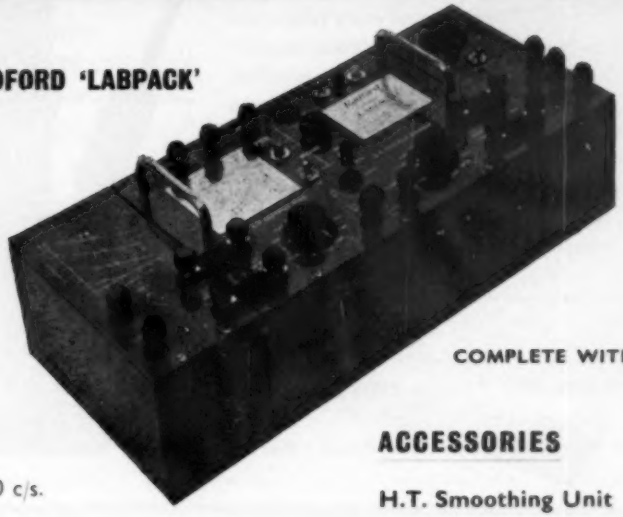

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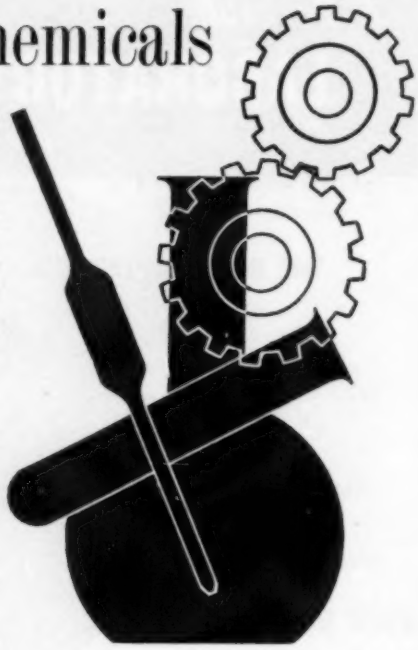

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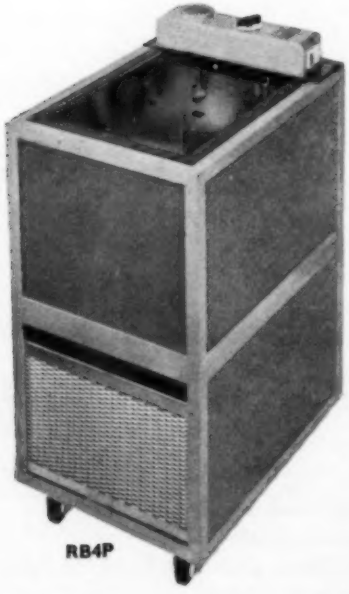

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Vol. 9 JULY 1960 No. 7

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EDITORIAL

The Royal Society 1660—1960

THIS number of our journal is dedicated to the Royal Society on the occasion of its celebrating the tercentenary of its foundation. It is a tribute from one of the newest organized scientific activities to one of the oldest. Indeed, from the point of view of what we understand as a scientific society today, the Royal Society may well claim to be the oldest. It was probably the first organized society which set out deliberately to test theories by experiment, and so *Laboratory Practice* may well be regarded as a spiritual descendant of that meeting held just 300 years ago.

This issue contains an account of the origin and history of the society by the Assistant Secretary, Dr. D. C. Martin, as well as a series of articles describing the contribution of Fellows in various branches of knowledge by distinguished members of our Scientific Advisory Committee. These speak for themselves, leaving us free to pay a tribute to the President of the Society, Prof. Sir Cyril Hinshelwood who has honoured us by writing a Foreword for this number.

Sir Cyril was recently honoured by the Queen with the Order of Merit, an order which is unique and reserved for distinction of intellect and is unassociated with any political, civil or military activity. It is symbolic of the times that a substantial proportion of the 24 members is scientific. These include Sir Robert Robinson, a former President of the Royal Society and a member of our Scientific Advisory Committee who contributes the article on Chemistry in this issue.

The tercentenary year is a fitting climax to Sir Cyril's long and distinguished career and his work for the Royal Society. Elected at the early age of 32, he has been awarded the Royal and Davy Medals. He received a Nobel Prize in 1956 and was President of the Chemical Society in 1947, its centenary year. There is not the space in one editorial to list all the honorary degrees, officer appointments in scientific societies and other honours which have been showered on him. One feature we should like to emphasize is the tremendous output of his scientific work and the width of his intellectual interests. In addition to many original papers in the Proceedings of the Royal Society and

other journals, he has published 'Kinetics of Chemical Change', 'Thermodynamics for Students of Chemistry', 'The Chemical Kinetics of the Bacterial Cell', and 'The Structure of Physical Chemistry'. In addition to this he is President of the Classical Association and speaks French, German, Italian, Spanish and Russian. His hobbies include painting and collecting Chinese porcelain. Any one of these activities would serve as a full-time occupation for an ordinary man, but Sir Cyril is an intellectual giant. Gone are the days when a scientist was a specialist with a one track mind and no interests outside his own branch of science. Many scientists today are keen amateurs (in the original sense of the word) of painting, music and literature, and often distinguish themselves in less intellectual hobbies and a variety of sports. They are proud to acknowledge Sir Cyril as their doyen and to pay tribute to the Fellows of the leading scientific society in the Commonwealth if not in the world.

Forthcoming Congresses

Ergonomics in Industry

Ergonomics, the study of man in relation to his working environment, is the subject of a three-day conference being organized by the Department of Scientific and Industrial Research at the Connaught Rooms, Great Queen Street, London, W.C.2, from September 27 to 29 inclusive.

The object of this conference is to bring recent ergonomic research and industrial application to the notice of senior people in industry and to show where ergonomics fits in with the interest of production engineering, equipment design, work study training and industrial health.

Ergonomics is concerned with the improvement of industrial efficiency by ensuring that equipment is within the mental and physical capacities of normal people, taking into consideration such factors as the complexity of the job, noise, lighting and temperature. Speakers at the conference will represent industrial concerns, medical services, the trade unions and academic institutions. They will discuss the benefits to industry of a combined approach by anatomists, physiologists and psychologists, along with engineers, to problems of 'fitting the job to the man'.

Further details of the conference can be obtained from Miss H. M. Clay, D.S.I.R., 14-18 Cornwall Terrace, Regent's Park, London, N.W.1. As accommodation is limited, early application is recommended.

Bureau of Analysed Samples

A record number of over 80 analysts representing all branches of the Metallurgical Industry, Government Departments and Research Association Laboratories attended a meeting in York on Tuesday, May 10, held by the Bureau of Analysed Samples, Ltd.

After an introductory welcome by Dr. E. Gregory, the Managing Director, Mr. P. D. Ridsdale, gave a report on the progress in the preparation of British Chemical and Spectrographic Standards during the three year period to November, 1959. His report stated that during this period five new standards had been issued: refined ferro-manganese No. 280, 13 per cent manganese steel No. 290, Lincolnshire iron ore No. 301 Northants iron ore No. 302, and iron ore sinter No. 303.

It also stated that the preparation of the following eight new chemical standards was now in progress: 10 per cent aluminium bronze, 6 per cent zinc aluminium alloy, 75 per cent ferro-silicon, magnesium alloy containing zinc and rare earths, Nimonic '90' alloy, 0·4 per cent carbon free-cutting steel, chrominium ore and Sillimanite refractory.

The two latter samples are being prepared at the request of the British Ceramic Research Association and the 0·4 per cent carbon free-cutting steel is being prepared at the request of the Association of Drop Forgers and Stampers.

In addition to work on new samples, replacements of no less than 36 standards have been prepared and issued during this period. These include three carbon steels, three alloy steels, three cast irons, four ferro-alloys, two basic slags, one iron ore, three aluminium alloys, two non-ferrous alloys, seven pure metals, and eight low alloy steels.

Mr. Ridsdale also announced that work on a further 10 replacement samples is in progress and that since the end of last year three of these have been completed and will be issued shortly, viz.: 0·3 per cent carbon steel No. 239/2, 1·2 per cent carbon steel No. 163/1, and bronze containing 3·5 per cent Pb and 0·5 per cent P No. 183/1.

Mr. Ridsdale mentioned that standardization of this bronze sample had given a number of laboratories an opportunity to try out several of the draft British Standard methods for the analysis of copper alloys which had been circulated to industry for comment and that the results obtained had proved that nearly all these methods are very satisfactory.

Turning to spectrographic standards, Mr. Ridsdale reported that a new series of low alloy steel spectrographic standards had been issued to replace the original series which was now exhausted. This new series is issued in the form of both the 1 in. sq. section bars and 1¼ in. dia. discs to meet the requirements of the spectrograph and all forms of direct reading instruments including vacuum direct readers.

Work is also nearing completion on a new series of plain carbon steel standards for direct reading instruments. This series which is being standardized for carbon, silicon, sulphur, phosphorus, manganese and arsenic, will be supplied in the form of 1¼ in. dia. discs for spectrographic work, but will also be available in the form of turnings for chemical analysis.

Probably the most important development in the field of spectrographic samples is a new series of cast iron standards for magnesium and nickel which will be available in the near future. This series, which is being prepared in conjunction with the British Cast Iron Research Association, will cover the range of 0·005-0·015 per cent Mg and 0·35-1·4 per cent Ni and will only be available in the form of 1·2 in. dia. bars for spectrographic analysis.

A steadily increasing demand both at home and abroad for chemical and spectrographic standards was reported and the fact that these standards have been exported to no less than 50 different countries during the last three years gives an indication of the world-wide recognition which they receive.

Foreign Members of the Royal Society

The following have been elected Foreign Members of the Royal Society:

Professor George Wells Beadle.—Chairman of the Division of Biology, California Institute of Technology, Pasadena, California, U.S.A. Distinguished for his outstanding contributions to genetics.

Prof. Ragnar Arthur Granit.—Professor of Neurophysiology, Kungl. Karolinska Mediko-Kirurgiska Institutet, Stockholm, Sweden. Distinguished for his researches on the physiology of vision and neurophysiology.

Prof. George Bogdan Kistiakowsky.—Professor of Chemistry, Harvard University, Cambridge, Massachusetts, U.S.A. Distinguished for his work in chemical kinetics of gaseous reactions, photochemistry, thermochemistry, and structure of polyatomic molecules.

Academician Lev Davydovitch Landau.—Professor of Theoretical Physics, S.I. Vavilov Institute of Physical Problems, Moscow, U.S.S.R. Distinguished for his contributions to theoretical physics.

FOREWORD

by

Prof. Sir Cyril Hinshelwood

O.M., M.A., D.Sc., F.R.S.

President of the Royal Society

IT is an apt refutation of the suggestion that the Royal Society is an 'exclusive Club' when a journal with the wide and practical interests of *Laboratory Practice* devotes a number to the occasion of the Tercentenary of the Society.

THE mandate given to the Royal Society in its Charter was to 'further the bounds of natural knowledge and the useful arts'. In celebrating the first three hundred years of activity the present members would gratefully and proudly maintain that their predecessors have indeed fulfilled the task which King Charles II set them. More modestly they will hope that they may be able to maintain the traditions handed down to them.

MANY things might be said of the three centuries. The results of careful and objective experiment have probably far surpassed the expectations of the founders, as the various essays contained in this issue of the journal bear witness. The nature of life and the nature of the universe are slowly being revealed. What is appearing is not a picture conjured up by speculation but one slowly pieced together by the application of the scientific method. The major tools of this method are the appropriate techniques of investigation, and these tools become more numerous and more complex as time passes. The study and mastery of technique and the invention of appropriate apparatus are indispensable elements in all scientific work, and the contents of this present volume provide many illustrations of the indissoluble unity of imaginative conception with the well judged choice of method.

C. N. Hinshelwood

THE ROYAL SOCIETY OF LONDON FOR IMPROVING NATURAL KNOWLEDGE

by D. C. Martin, C.B.E., Ph.D.

Assistant Secretary, The Royal Society

Dr. D. C. Martin at his desk in the Royal Society's Rooms in Burlington House. The tall clock behind him to the right was made by John Shelton about the middle of the 18th century. It is of a regulated type commonly used in astronomical observations; it was taken overseas by ship several times to observe the transit of Venus, and was used by two English astronomers—Charles Maxon and Jeremiah Dixon—between 1763—1767 during the survey carried out in the then British colony of America which resulted in the fixing of the famous Mason-Dixon line between Maryland and Pennsylvania.
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SIR CYRIL HINSHELWOOD, O.M., the reigning President of the Royal Society in its tercentenary year, is the successor of a long line of men of great distinction who have each been the chosen representative of the private group of scholars, first formed in 1660, to encourage the improvement of natural knowledge. Mention need only be made of Wren, Newton, Banks, Davy and Rutherford, to exemplify the quality of some of those who, by their genius, have adorned what has become the greatest scientific appointment in the world. The Society's renown depends principally on the sum total of innumerable contributions of its Fellows to new knowledge, and the encouragement given by the Society in its corporate activities takes the form of providing a means of publication, sometimes financial help, and a sensitive mechanism for consultation and exchange of views on every kind of scientific matter. As Sir Cyril has remarked 'The Society is its Fellows and its Fellows are the Society.'

Origin and Founders

In the early days of the seventeenth century a new outlook was gaining a hold on a few of the intellectual leaders of the time. In England, Gilbert, Queen Elizabeth's physician, showed by experiment that the earth itself was a magnet and Harvey, by experiment, demonstrated the circulation of the blood. In Italy Galileo's experiments challenged accepted views and elswhere in Europe the new experimental philosophy was being thought and talked about. Francis Bacon, although himself no contributor to experimental science, had written about it in a book called *The New Atlantis* which went through ten editions in the 43 years after its publication in 1627, a year after he died. This evidence of interest in the experimental method of research, as opposed to the hitherto accepted deductive method, is all the more surprising when one recalls the turbulent years of this period in England. The military republic was not conducive to philosophical meetings—Robert Boyle had thoughts of emigrating to North America because he believed conditions would be better there for his experimental philosophy. Neverthe-

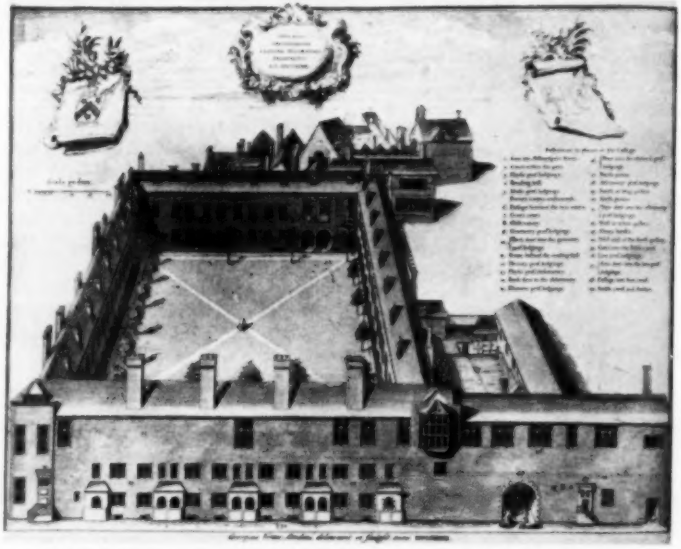

Fig. 1. Gresham College.

less, there is evidence of meetings of philosophers in the City of London as early as 1645 where Gresham College (Fig. 1) provided a focus for learning. Some of those who met later went to Oxford, where meetings also took place sometimes in Wadham College, and there clearly existed a desire to encourage the experimental method of studying natural phenomena. With the restoration of the Monarchy, King Charles II, who had several scientific pursuits himself, brought with him a number of courtiers, notably Sir Robert Moray, who were also interested in the new philosophy. Within a few months of the restoration the step of creating a formal body was taken. The decision to found 'a Colledge for the promoting of Physico-Mathematicall Experimental learning' was taken on November 28, 1660 by a group of natural philosophers meeting in Gresham College after a lecture given by the 28 year old Gresham Professor of Astronomy, Christopher Wren. Others present included Lord Brouncker, Robert Boyle, Sir Robert Moray, John Wilkins (in the chair) and William Petty. Within a week Sir Robert Moray, a soldier, statesman and scientist, whose importance to the Society cannot be overestimated 'brought in word from the Court that the King had been acquainted with the designe of this meeting. And he did well approve of it and would be ready to give encouragement to it.' Meetings thereafter took place once a week 'in tearme time' and Fellows each contributed a shilling a week to meet the costs involved. Mainly through the efforts of the Royalist Fellows led by Moray a charter was prepared and passed the great seal on July 15, 1662. A second charter, which states the Society's purpose and governs its affairs to this day, gave the Society its full title as 'The Royal Society of London for improving Natural Knowledge'. In the Society's possession are several highly prized tangible links with those early years, including the journal book recording the meetings begun in November 1660 and two magnificent gifts from the King, a Mace and the Charter or Signature Book in which King Charles II inscribed his name followed by the word 'founder'. Her Majesty Queen Elizabeth II is the thirteenth monarch to continue the tradition of Royal patronage and she has graciously consented to open the Tercentenary Celebrations this year at the Royal Albert Hall. The signature book is still in use and it contains the signatures of all Fellows and Foreign Members who have been formally admitted to the Society since it was presented by the founder. At the opening ceremony of the Celebrations King Gustav VI Adolf of Sweden, elected last year, will add his signature to those of the numerous distinguished scientists of the world who have already done so.

The First Century

The mid-seventeenth century founders of the Royal Society were men of outstanding merit and foresight. They were soon joined by others equally enthusiastic in their dedication to the new philosophy. They believed that the study of nature could be most successfully prosecuted and advanced by means of experimental research. Within a hundred years Fellows had achieved much, Christopher Wren had made great contributions to mathematics and astronomy, as well as displaying unparalleled genius in architecture. Robert Boyle's discoveries had yielded fundamental physical laws. His laboratory assistant, Robert Hooke, who had been appointed the Society's first curator of experiments for the weekly meetings, had, among his many highly significant experimental studies, constructed his compound microscope (Fig. 2) and made many new discoveries with it which he described in *Micrographia* issued in 1665 under the Society's *imprimatur*.

Fig. 2. Hooke's own microscope. *Crown copyright, Science Museum, London.*

In 1671 a young man of 29 years of age was elected. He was destined to ornament natural philosophy in a manner unexcelled by anyone since and to bring the Society great renown through his brilliant and illustrious work. Later the same year Isaac Newton (Fig. 3) for it was none other, presented the Society with his reflecting telescope (Fig. 4) still a treasured possession, and in the years that followed he had been persuaded to publish his fundamental work on the nature of light and the gravitation theory of planetary motion. In 1687 the Society published Newton's great book *Philosophiae Naturalis Principia Mathematica*, usually known as the *Principia*, described by Laplace as 'pre-eminent above any other production of human genius.' He was a most attentive and conscientious occupant of the presidential

Fig. 3 (*left*). **Sir Isaac Newton, P.R.S. and** (*above*) **his reflecting telescope (Fig. 4).**

chair from 1703-1727 and added even greater lustre and renown to the Society.

During its first century Huygens, Malpighi, Leibniz and Leeuwenhoek had been among the distinguished foreigners elected into the Fellowship and who had made outstanding contributions to the creation of the scientific age. Henry Oldenburg had begun in 1675 the *Philosophical Transactions* (Fig. 5) to give through the medium of the press 'some Accompt of the present Undertakings, Studies and Labours of the Ingenious in many considerable parts of the World' and so contribute 'to the Grand design of improving Natural Knowledge, and perfecting all Philosophical Arts, and Sciences'. In this way he established the world's senior scientific journal. He had had the support of the Fellows, notably John Wilkins who, with Oldenburg, was one of the Society's first two Secretaries, in a determined and successful attempt to improve the English language in its form and use to 'clearly and truly communicate', an accomplishment which had an impact well beyond scientific writings. Edmond Halley, as well as making contributions to astronomy, had voyaged to make the first magnetic chart of the oceans and had also served for 13 years as the Society's most distinguished Assistant Secretary. Hans Sloane, physician and a great natural historian, whose collections became the basis of the British Museum, had succeeded the immortal Newton in the Presidential office.

The Second Century

The period of 1760-1860 is dominated by the figure of Sir Joseph Banks (Fig. 6) who was elected in 1766 at the age of 23 and when 35 became President, in which office he remained for nearly 41 years (1778-1820). Joseph Banks, botanist and explorer, who took part in voyages with James Cook, was a very celebrated man who became a close friend of King George III, a generous benefactor of the Society. Banks used to the full his considerable personal wealth and his influence to enhance the Society's wellbeing and the Society's prestige, both at home and abroad, greatly benefited by his activities. In addition to his own botanical contributions—he was in all but name the first Director of Kew Gardens—he did a great deal to encourage astronomy, meteorology, geodesy and geographical exploration. Such was his renown that during the Napoleonic wars he was not only able to arrange safe conduct for British scientists journeying in France but was in correspondence with French men of science to whom he gave considerable help in their scientific endeavours. Just before and during the early days of Banks' presidency Benjamin Franklin, a close friend of the Society, took an active part in the Society's affairs and later, after Franklin, then American Envoy in Paris, had instructed American men of war not to interfere with James Cook on his scientific voyages, Banks sent to Franklin a generous letter of appreciation and one of the gold medals struck by the Society in honour of Cook. At this time Henry Cavendish and James Watt were making their fundamental contributions to the composition of water, Herschel discovered Uranus, and Volta was sending the Society accounts of his electrical discoveries. It was also the period when Priestley, Dalton, Wollaston, Davy, and

PHILOSOPHICAL
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OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For Anno 1665, and 1666.

In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane,
Printers to the Royal Society.
Presented by the Author May 30th 1667.

Fig. 5. Title page of Philosophical Transactions.

Faraday were making their brilliant and fundamental discoveries.

The second century of the Society also witnessed the great developments in biological sciences, to which Linnaeus, elected in 1753, Charles Lyell, Joseph Hooker, Thomas Henry Huxley, had made contributions and which culminated in the publication of Charles Darwin's 'Origin of Species' in 1859.

From 1820 to 1827 Sir Humphrey Davy steered the Society's affairs. He was succeeded by Davies Gilbert and in 1830 H.R.H. the Duke of Sussex, the sixth son of King George III, became the Society's first, and until now, only Royal President. He helped the Society in many ways and introduced the practice of the annual issue to all Fellows of a statement of the Society's accounts. Under Davy there had been some disquiet about the lack of scientific qualifications among some of the many new Fellows being elected. This movement grew but it was not until 1847 that a thorough reform took place. Council decided then to nominate one day in the year for the annual elections, to restrict the number of elected to 15 and to circulate to all the Fellows the names and claims of all the candidates. In 1847 the Fellows numbered 764, by 1860 it had fallen to 630, of whom 330 were scientific men so that they, for the first time, constituted the majority of the Fellowship. This was a landmark in the Society's history; the number and quality of the papers in the *Philosophical Transactions* rose to higher standards and the Council membership from that date tended towards and is now almost exclusively of qualified men of science devoted to the improvement of natural science.

The Third Century

The Society was now set on a course where, more than ever before, originality and high quality in research was an essential quality of election. Because of this requests began to be made to it to undertake additional tasks on behalf of the Government; for instance, in administering a grant of £1,000 for the promotion of scientific enquiries.

After the presidency of General Sabine (1861-1871) it was agreed on the suggestion of Sir Joseph Hooker, his successor, that no one should be expected to hold the presidency for more than five years, a practice which has been followed ever since. Among those who followed Hooker as President were Thomas Henry Huxley (1883-1885), Sir George Gabriel Stokes (1885-1890), Lord Kelvin (1890-1895), and Lord Lister (1895-1900). After 1900 the great developments in physics are reflected in the Presidencies of Lord Rayleigh (1905-1908), Sir William Crookes (1913-1915), J. J. Thomson (1915-1920), Lord Rutherford (1925-1930), and Sir

Fig. 6. Sir Joseph Banks, P.R.S.

William Bragg (1935-1940), while Sir Charles Sherrington (1920-1925), Sir Frederick Gowland Hopkins (1930-1935), Sir Henry Dale (1940-1945) and Lord Adrian (1950-1955), each of whom have made outstanding personal contributions to physiology or biochemistry, represent the biological sciences. Sir Robert Robinson (1945-1950) and Sir Cyril Hinshelwood (1955-) have by their researches greatly advanced chemical science and by their leadership of the Society most worthily maintained the standards of their predecessors.

The corporate activities of the Society have greatly increased in the past century especially within the last two decades. Its publication programme is no longer limited to the *Philosophical Transactions* but it also publishes the *Proceedings of the Royal Society*. Last year nearly 300 papers were published in spite of the printing industry dispute. The regular publishing programmes also include two issues annually of *Notes and Records of the Royal Society*, currently edited by Sir Harold Hartley, the Society's *Year Book* and the valuable *Biographical Memoirs of Fellows of the Royal Society*. The Society also issues a series of *Mathematical Tables*, three volumes of which are due to appear this year.

Two books will be published by the Society on the occasion of the tercentenary. The first is *The Royal Society, its origins and founders* edited by Sir Harold Hartley, a valuable reappraisal by some 20 authorities of the Society's early days, and the second is a well illustrated *Brief History of the Royal Society* by Prof. E. N. da C. Andrade. It is particularly fitting that the first volumes of a major work *The Correspondence of Sir Isaac Newton* are also appearing in this tercentenary year.

The work undertaken by the Society has increased so much that Council has had to devolve much of it to committees and sub-committees, which now number 115 in all. In domestic affairs there are a number of committees to deal with the finances, the Society's library, its annual conversaziones, and so on. The most important are, however, the Sectional Committees, one each for mathematics, physics, chemistry, engineering sciences, botany, geology, zoology, the physiological and medical sciences. These Sectional Committees are concerned with publication but their most important activity is advising Council on the selection of candidates for election into the Fellowship. This is a very difficult task as only 25 are selected from a number of candidates which usually now exceeds 300 persons. It is a task undertaken with the greatest possible care and attention.

Another group of committes advise on the Society's some 30 research appointments, made possible by funds entrusted to the Society by benefactors, the latest of which is a gift of £200,000 from the Isaac Wolfson Foundation to endow a greatly valued research professorship. Another group of committees is jointly appointed with other bodies, e.g. with the Science Masters' Association for encouraging schoolmasters who wish to do research or with the Nuffield Foundation in the operation of a Commonwealth Bursaries Scheme for research workers of proven merit.

But more than 50 of the Society's committees are concerned with international relations. The Society is the agency in the United Kingdom for the conduct of international relations in pure science. Since 1660 intercourse with scientists throughout the world has always been assumed as a natural and regular activity of the Society as has already been indicated and today as ever the Society enjoys the friendliest relations with its sister Academies throughout the world. Co-operation of a more formal kind can be regarded to have begun about 1898, shortly after which the International Association of Academies was formed. After the first World War this became the International Research Council, to which the Royal Society was appointed as the British adhering body. In 1931 the International Research Council became the International Council of Scientific Unions (ICSU), the membership of which consists of national members (i.e. Academies) and scientific members (i.e. international scientific unions) of which there are 13 at present. The ICSU is becoming a body of considerable force in world scientific affairs and among its recent achievements was the organizing of the International Geophysical Year (IGY) by a specially appointed international committee. It has now set up special committees for Space Research (COSPAR), Antarctic Research (SCAR) and Oceanic Research (SCOR). For the conduct of relations with all these special committees and 12 of the international scientific unions the Royal Society has appointed advisory British National Committees. The British National Committee concerned with the IGY, on behalf of the Council of the Royal Society, co-ordinated the British contribution to the IGY, including the highly successful expedition to Antarctica where at Halley Bay the Royal Society IGY base operated from 1956-58. The British National Committee for Space Research is currently co-ordinating, in relation to COSPAR, Britain's scientific space research programme which is extremely active and developing rapidly. On the Society's British National Committees 83 national research organizations are represented and some 800 persons, the majority outside the Fellowship, are members.

This undertaking of international scientific relations, supported by a Parliamentary Grant-in-Aid, is but one of the public responsibilities discharged by the Society. It administers two other Parliamentary Grants-in-Aid, one for scientific investigations and expeditions and the second for scientific publications and libraries. The Society is also called upon to be represented on many governing bodies. These include the boards of public schools, university courts, research institutions, and many committees concerned with scientific research. Over one hundred Fellows serve in this capacity. The President is, *ex officio*, a trustee of the British Museum, The Times Publishing Company Ltd. ('Committee of Trustees'), the Spectator Committee and a number of

other Trusts. Acts of Parliament require all appointments to the Medical Research Council, the Agricultural Research Council and the Council for Scientific and Industrial Research as well as some other governmental research committees to be done in consultation with the President. The President and Council are 'the constant visitors' of the Royal Greenwich Observatory and they are also responsible for the scientific programme of the National Physical Laboratory.

The Society has been called upon to carry these many responsibilities because of the quality of its Fellowship and the maintenance of the highest standards in making its annual elections is the best guarantee of the continuance of the Society's great influence today.

The Fourth Century

The Society is in good heart as it embarks on its fourth century. It is receiving the greatest encouragement from the support, national and international, which is being given to its Tercentenary Celebrations. What the future holds cannot be foretold with certainty but we can confidently expect that Fellows of the Society will continue, each in their individual way, to explore the endless horizons of knowledge, that international scientific co-operation will be intensified and that in the conditions of the world of tomorrow the Society will play its part to ensure that the improvement of natural knowledge can proceed in a way which will continue to be to the benefit of mankind.

Royal Society Fellows

The following Fellows were elected to the Royal Society on March 24, 1960:

Binnie, Mr. Alfred Maurice. Reader in Engineering at the University of Cambridge, Department of Engineering. Distinguished for his contributions to engineering science.

Brown, Prof. Robert Hanbury. Professor of Radio Astronomy in the University of Manchester, Jodrell Bank Experimental Station. Distinguished for his many contributions to radio astronomy.

Christopherson, Prof. Dermon Guy, O.B.E. Professor of Applied Science in the University of London, Imperial College of Science and Technology, Department of Mechanical Engineering. Distinguished for his researches into the deformation and cutting of metals and for his work on explosive weapons.

Dalitz, Prof. Richard Henry. Professor of Physics in the University of Chicago, Enrico Fermi Institute for Nuclear Studies. Distinguished for his numerous contributions to nuclear theory and the physics of elementary particles.

Davidson, Prof. James Norman. Gardiner Professor of Physiological Chemistry in the University of Glasgow. Distinguished for his work on the structure, distribution and biosynthesis of ribose nucleic acid and deoxyribose nucleic acid.

Dewar, Prof. Michael James Steuart. Professor of Chemistry in the University of Chicago. Distinguished for his studies of chemical structure and for his contributions to the application of quantum theory to organic chemistry.

Duke-Elder, Sir Stewart, G.C.V.O. Opthalmic Surgeon and Director of Research at the London University Institute of Ophthalmology. Distinguished for his contributions to ophthalmic medicine, pathology and physiology.

Essen, Dr. Louis. Deputy Chief Scientific Officer at the National Physical Laboratory, Teddington, Middlesex. Distinguished for his work on the precise measurement of frequency and of the velocity of light.

Evans, Dr. David Gwynne. Director of the Medical Research Council Biological Standards Control Laboratory, London. Distinguished for his investigations on the pathogenesis and prophylaxis of anaerobic wound infections and whooping cough, and on biological standards.

Falcon, Mr. Norman Leslie. Chief Geologist of the British Petroleum Company, London. Distinguished for his researches in tectonics and stratigraphy.

Gorer, Dr. Peter Alfred. Reader in Experimental Pathology at the University of London, Guy's Hospital Medical School. Distinguished for his work on the immunological genetics of tissue transplantation.

Heath, Prof. Oscar Victor Sayer. Professor of Horticulture in the University of Reading. Distinguished for his work in plant physiology particularly the mechanism of stomata.

Holroyd, Dr. Ronald. A Deputy Chairman of Imperial Chemical Industries Ltd., London. Dist inguished for his work on the chemistry and engineering of synthetic fuel production.

Huxley, Dr. Hugh Esmor, M.B.E. Member of external staff of the Medical Research Council, Department of Biophysics, University of London, University College. Distinguished for his work on the fine structure of muscle and on the mechanism of muscular contraction.

Kendrew, Dr. John Cowdery, Deputy Director of the Medical Research Council Unit for Molecular Biology, Cavendish Laboratory, Cambridge. Distinguished for his work on the three-dimensional analysis of myoglobin by direct x-ray diffraction methods.

Kitching, Dr. John Alwyne, O.B.E. Reader in Zoology at the University of Bristol, Department of Zoology. Distinguished for his contributions to the physiology of protozoa and to marine ecology.

MacDonald, Dr. David Keith Chalmers. Principal Research officer, Division of Pure Physics, National Research Council of Canada, Ottawa. Distinguished for his investigations of the thermal and electrical properties of metals.

Pickering, Sir George White. Regius Professor of Medicine in the University of Oxford, Department of Medicine. Distinguished for contributions to clinical science, particularly of the causes of high blood-pressure.

Porter, Prof. George. Professor of Physical Chemistry in the University of Sheffield, Department of Chemistry. Distinguished for his work on flash photolysis and its applications to the study of free radicals and chemical processes.

Roth, Dr. Klaus Friedrich. Reader in Mathematics at the University of London, University College, Department of Mathematics. Distinguished for his solutions of fundamental problems in the theory of numbers.

Seshadri, Prof. Tiruvenkata Rajendra. Professor of Chemistry in the University of Delhi, Department of Chemistry. Distinguished for his studies of the chemistry of naturally occurring compounds, particularly flavonoids.

Taylor, Prof. James Haward. Professor of Geology in the University of London, King's College, Department of Geology. Distinguished for his researches into the geology of ore deposits, particularly the iron ores of the Midlands.

Townsend, Dr. Albert Alan. Assistant Director of Research at the University of Cambridge, Cavendish Laboratory. Distinguished for his experimental and analytical contributions to the theory of turbulent motion in fluids.

Wain, Prof. Ralph Louis. Professor of Agricultural Chemistry in the University of London, Wye College, Department of Physical Sciences. Distinguished for his research in plant auxins and systemic herbicides.

Willmer, Dr. Edward Nevill. Reader in Histology at the University of Cambridge, Department of Physiology. Distinguished for his work on cells and colour vision.

PHYSICS

by Prof. S. Tolansky, F.R.S.

Professor of Physics, Royal Holloway College, University of London

Prof. S. Tolansky, F.R.S.

THE HISTORY of physics associated with the Royal Society is, in effect, the history of physics in England. So rich are the associations that nothing less than a succession of massive biographies would be needed to do justice to the subject, for a dazzling succession of distinguished physicists appear in the Record of the Royal Society itself. The original Fellows, all of whom were elected in 1663, included among them Robert Boyle and Robert Hooke. It was Boyle's 'Sceptical Chemist' of 1661 which broke away from the old four elements, and Hooke was a physicist whose experimental genius may have since been equalled, but has rarely been surpassed. Newton was elected to the Fellowship in 1672, aged 31. By then, he had already dazzled scientific Europe with his binomial theorem, his calculus, his reflecting telescope, and the first formulation of his theory of gravity. In 1686 the *Principia*, a work frequently described as the greatest single contribution to scientific knowledge made by any one man, was presented at the Royal Society and it was then published a year afterwards. In 1703 Newton was elected President of the Royal Society, holding that office for no less than 24 years, a unique distinction. This period saw the election as Fellows of Halley, the astronomer and oceanographer, Hawksbee of vacuum-pump fame, the Bernoullis, and Bradley who discovered stellar aberration.

The latter half of the eighteenth century is also liberally sprinkled with distinguished physicists, among whom were Benjamin Franklin, known for his work in electricity, and who received the Copley Medal in 1753. The list of the Royal Society Bakerian lectures contained at this time lectures given by Ingen-Hausz (1778), who was elected to the Fellowship in 1769. Count Rumford appeared on the list of Fellows in 1779, while Herschel was awarded the Copley Medal for 1781.

One of the most outstanding of European physicists at the turn of the eighteenth century was Thomas Young, who, in 1800, 1801 and 1803 delivered the Bakerian lectures on optics, on colour vision and on interference. Young was one of the most remarkable men of his age, and his memory is not only enshrined in optics, in elasticity, and the wave theory of light, but equally as the man who first led the way to the analysis of Egyptian hieroglyphic writing. He was indeed a giant.

A distinguished contemporary was Wollaston, who was President of the Royal Society in 1820, and made formidable contributions to optics, spectroscopy and crystallography. Sir Humphrey Davy was one of the brilliant galaxy of stars at that time.

It is perhaps worth while pausing in this inadequate brief sketch to consider the situation in the physical sciences just at the half way mark in our tercentenary celebration, say at 1810, when the Royal Society was 150 years old. There certainly was revolution in the air with regard to the physical sciences. It seems as if the intellectual inspiration triggered off by the French Revolution was making its mark in science also. Chemistry was in a state of seething ferment. Black, Priestly, Lavoisier and Cavendish routed the supporters of the phlogiston theory, although indeed the phlogiston concept had much to commend it at the time. In 1808 Dalton already had laid the foundations of his atomic theory in a paper read in Manchester. Davy, equally distinguished as chemist and physicist, was isolating new elements, Wollaston was discovering palladium and rhodium and was the first to notice atomic absorption lines in the solar spectrum.

No less significant was the revolution in physics. Here it must be interpolated that at no time did the Royal Society as a corporate body guide or deflect these developments. On the contrary the advances were essentially individual contributions by separate Fellows. The importance of the Royal Society at the time was that the Philosophical Transactions was the vitally important medium for the communication of scientific discoveries, and so for the extension of scientific knowledge. Thus Davy, during his 28 years of active scientific life, contributed no less than 46 memoirs to the Philosophical Transactions.

The revolution in physics at this time was intimately tied up with that in chemistry. There was, however, a difference, for the immense authority of Newton had led to some hesitancy in physics. Astronomy had made immense strides. Techniques had been developed and telescopes had been built, a mass of new observational data had become available and Fellows like Flamstead, Halley, Bradley and Herschel, to mention but a few of the stars shining in the galaxy of astronomical genius and talent, had made great advances in observational data and in observational astronomy. Following Newton, a succession of distinguished continental mathematicians had developed the application of mathematical techniques to the analysis of physical phenomena, culminating in the great work of Laplace. The first two volumes of the Celestial Mechanics of Laplace appeared in 1799 and this great work has been placed second only to the *Principia* of Newton. Mathematical physics had matured to giant stature and the authority of its founder, Newton, was supreme.

Developments in some other branches of physics lagged curiously behind, largely, it is certain, because of the absence of organized laboratory facilities. Knowledge about heat and thermodynamics was in its infancy, although Rumford had already made his notable discovery of the relation between mechanical work and heat. Despite the ancient early knowledge of the magnetic lodestone and of frictional electricity, progress in this field was meagre and had still to await the genius of Faraday, Ampère, Clerk Maxwell and others. In that branch we now call properties of matter, there had been notable advances. Surface tension, elasticity and other mechanical properties were under vigorous investigation. The shape and size of the earth was quite well known and the eccentric Cavendish had made this remarkable measurement of the weight of the earth. It would of course be ridiculous not to recognize that physics in England (which is virtually synonymous with physics linked to the Royal Society) was intimately bound up with physics in other lands, yet the fact remains that without the formidable contributions of the Fellows of the Royal Society, science as such would be far behind where it is today. This article is not a history of science or a history of the Royal Society. It is merely a review of the contributions made to physics by but a few of the Fellows of the Royal Society, and of course these contributions were closely linked with the work done by physicists in other lands. The revolution against the authority of Newton came, strangely enough, in optics, and the challenger was the brilliant Thomas Young. The episode has a curious history. Newton had a deep interest in optics which occupied him off and on during the whole of his scientific career, from the discovery of the spectrum in 1666, to the publication of his last scientific work, 'Opticks' in 1704. He was well aware of Grimaldi's early demonstration of diffraction of light at an edge and had of course himself made fundamental studies of interference in thin films, viz. the Newton colour scale and the phenomena we now call Newton's rings. With his profound knowledge and understanding of physical processes one might have expected him to develop a wave propagation theory of light, for he well understood the mechanics of propagation of sound waves. But there was one curious stumbling block. He was aware of Huygens' discovery of double refraction and polarization of light by calcite. Now at the time no one had yet conceived the idea of propagation of a wave with transverse vibrations. The sound wave he rightly understood as compression and rarefaction states in the line of propagation itself. Newton realized it was impossible to explain polarization by a compression-rarefaction wave, and as this was the only propagation wave he recognized, he abruptly abandoned the wave theory and introduced his celebrated corpuscular theory of light. Somewhat obscurantist, Newton proposed that the light 'corpuscles' could be subject to easy fits of transmission and easy fits of reflection and on this mechanistic basis accounted for the Newton's rings and indeed computed the distance travelled between such fits, what in fact we now call the wavelength; and his value was good. Diffraction at an edge he likewise accounted for in terms of an inflection of the corpuscles at the edge.

Now to oppose the views of the authoritative Newton required considerable courage, but Thomas Young, in a series of brilliantly conceived and brilliantly executed elementary demonstrations of the interference of light, established the basic correctness of the wave theory once and for all, and soon Fresnel and Arago in France, and Brewster and Herschel in this country, lent massive support to Young's views. The revolution was achieved. Wave propagation became accepted and the way was prepared for the later profound development of the electromagnetic theory of energy propagation, a theory to be the central core of the whole of 19th century physics.

A branch of physics which was to have most important repercussions on technology was the foundation in the early years of the 19th century of the electrical sciences. Really started by Oersted in Denmark, Ohm in Germany and Ampère in France, it was essentially brought into full manhood by the genius of Faraday, in this country. The election of Faraday to the Royal Society in 1824 was marred by violent opposition from Davy, but, in due course Faraday's genius was recognized and he was awarded the Copley Medal in 1832 and the Royal Medal in 1835. Faraday has rightly been called by a science historian of the period the prince of experimenters and his fundamental discoveries led to the ultimate industrial generation of electricity with its associated revolutions in human activities. His work on electrolysis was equally striking and a common terminology such as electrode, anode, cathode, etc., is due to him. Faraday has been called the greatest physicist of the 19th century and it is reported that Einstein classed him with Galileo, Newton and Clerk Maxwell as one of the four main names in the history of physics. Most of his research work was published by the Royal Society but he shunned meeting people, rarely visiting the Society and even rejecting an offer of the position of

President made to him in 1857. He was shy and reserved. One interesting research by Faraday is worthy of mention. In 1825 he was asked by a Royal Society committee to undertake the study of optical glass and in due course, in 1829, this work became the subject of Faraday's Bakerian lecture which was in fact so lengthy that three sittings were required to complete it! Faraday's distinction as a scientist was equalled by his reputation as a lecturer. His conception of lines and tubes of force in electromagnetism played a vital part in theoretical developments later. His contributions extended to many branches of physics, including the condensing properties of gases, even in fact to the concept of colloidal particles, a concept well ahead of his time. His discovery of benzene alone justifies including him in an important place in chemical technology. Throughout his life he was of the opinion that Fellowship of the Royal Society was too wide and should strictly be restricted to practising scientists.

Contemporary with Faraday were many less notable, yet nevertheless quite distinguished Fellows who made solid contributions to physics in many fields, most of it published in the Philosophical Transactions. We see in the Record of the Royal Society, looking merely at the list of the Bakerian lectures alone, Wollaston describing his researches on the noble metals, Fox Talbot, inventor of photography, writing on the optical characters of crystals, Airy the astronomer making fundamental contributions to optics, Forbes contributing to heat flow, Wheatstone producing his classic bridge circuit, which is a fundamental basis in electrical instrumentation, Graham writing on osmosis and diffusion, and both Tyndal and William Thomson (later Lord Kelvin) reading papers on electrical and magnetic properties of metals.

We arrive at the bi-century of the Royal Society in a furore of intense scientific activity, intense in every branch, mathematics, physics, chemistry, biology, medicine and engineering. Associated with the development of sources of power and energy the subject of thermodynamics emerged, and here Joule of Manchester and William Thomson of Glasgow made formidable contributions. Joule's schoolmaster was in fact Dalton, and the influence of Dalton on the younger man was important.

Joule had some early unfortunate relationships over publication with the Royal Society, but later the Society gave Joule a grant towards the cost of equipment for his experiments on the mechanical equivalent of heat. Joule had the habit of announcing his more important results to the meetings of the British Association rather than anywhere else.

Contemporary with Joule, indeed a collaborator, was the versatile William Thomson, the prodigy who matriculated at Glasgow University at the age of 10, published a dozen papers before graduating and was appointed Professor of Natural Philosophy at the age of a mere 22 years, holding his Chair for no less than 52 years! His contemporaries rated him intellectually very highly indeed and apart from a fantastically varied output of highly original scientific work he was also a sound man of business, and made a large fortune from engineering patents. Electricity, thermodynamics and the development of electrical engineering all owe a great debt to him. A major contribution was his application of physical methods into electrical communications. Kelvin formulated the law of conservation of energy and the second law of thermodynamics, and was one of the first to attempt to estimate the age of the earth.

An outstanding contribution of Kelvin was the organization of the very first physics laboratory in this country for the *teaching* of practical physics, naturally a vitally important step for later generations. The familiar mirror galvanometer is just one small example of his numerous inventions which have persisted until today. He was Copley Medallist in 1883 and was President of the Royal Society from 1890 to 1895.

The scientific richness of this period culminated in James Clerk Maxwell who, in the words of Max Planck 'achieved greatness unequalled'. He was the first professor of experimental physics at the University of Cambridge and created the Cavendish Laboratory. He, too, was an early prodigy. Kinetic theory of gases, experiments on colour perception and above all his great electromagnetic theory are just some of the fields he illuminated with his brilliance. Maxwell invented statistical mechanics in developing his kinetic theory of gases and this work on gases is considered to be outstanding by its original brilliance. His electromagnetic theory was the direct inspiration to Hertz when the latter made his important discovery of the propagation of radio waves. Maxwell was a Rumford Medallist in 1860 and his Bakerian lecture in 1866 dealt with the viscosity of gases.

Hard on the heels of Maxwell at the Cavendish laboratory came J. J. Thomson. Another child prodigy, he succeeded Lord Rayleigh who had held the Cavendish Chair for an interim period of five years, and in 1884 Thomson was appointed at the very early age of 28. Not only did he identify the properties of the electron, but his later work on positive rays led to the nuclear mass spectroscope which is equally fundamental. J. J. Thomson was the creator of a great modern school of atomic physicists. He had command of a formidable mathematical equipment, was an imaginative theorist and had a profound understanding of experimental methods, although he himself is reputed not to have been very expert with his hands. It was from the school of J. J. Thomson that immense developments came relating to the discharge of electricity in gases, and from these came such fields as the knowledge of the electron, the mass spectroscope, thermionics, x-ray scattering and other aspects of modern physics. Modern atomic physics was born in J. J. Thomson's laboratory. He was the President of the Royal Society from 1915-20, Copley Medallist in 1914, Royal Medallist in 1894 and the first Hughes' Medallist in 1902. He gave the Bakerian lecture on electrical discharges through gases in 1887, and again on positive rays in 1913. He

and his pupil, Rutherford, created modern atomic physics.

On Rutherford fell the mantle of experimental genius worn earlier by Faraday. Rutherford's vigorous yet visionary approach created nuclear physics, which perhaps can be regarded as essentially the physics of the future. Rutherford's three major achievements, which he secured with ridiculously simple means, were first, the establishment of the mechanism of radioactive decay, a matter of considerable complexity requiring great experimental skill as well as visionary genius; second, the evolution of the nuclear concept of atomic structure, i.e. the Rutherford Atom, and third, the induction of the artificial transmutation of elements by atomic collisions. This latter of course led ultimately to the exploitation of nuclear energy. His direct brilliant simplicity in experimentation remains a constant source of wonder. Rutherford's memory and his work are too fresh to need much emphasizing for he is of course a contemporary. He was a powerful, heroic, indeed a Homeric, figure, immensely active and dynamic and a permanent source of inspiration to all who worked under him. Rutherford was intimately associated with the Royal Society. He was President 1925-30, Copley Medallist in 1922. His 1904 Bakerian lecture was devoted to radioactive transformations, and again in 1920 his Bakerian lecture was concerned with the atomic nucleus. The Royal Society also gave Rutherford considerable funds for the development and maintenance of a low temperature laboratory at the Cavendish.

The story of physics and the Royal Society continues. It is impossible to mention even a small fraction of the distinguished men who have been associated with the Royal Society. Even the list of those within living memory is imposing. There are O. W. Richardson, W. H. Bragg, A. Fowler, Aston, Lord Rayleigh, Jeans, Callendar, Poynting, Larmor, Dewar, Schuster, Boys and many others. Truly indeed can it be said that there is total identity between the Royal Society and the development of physics, not only in this country, but the development of physics in the whole world.

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Amalgamation of The Institute of Physics and The Physical Society

The incorporation of a new body on May 17, under the name of 'The Institute of Physics and The Physical Society' marks the fulfilment of the desire expressed by the overwhelming majority of the members of the Institute and Society that the necessary action should be taken to implement the scheme for amalgamation prepared by a Joint Committee. The originating bodies will shortly be formally wound up and their assets handed over the the new one.

The first President of the amalgamated body is Sir John Cockcroft and the four Vice-Presidents are Dr. J. Topping, Dr. W. H. Taylor, Prof. R. W. Ditchburn and Mr. A. J. Philpot, each responsible to the Council for a defined area of the many activities to be taken over by the new organization from its predecessors. The Presidents of the predecessors (Sir George Thomson and Mr. J. A. Ratcliffe) are also members of the new Council. The other Officers are Dr. J. Taylor (Honorary Treasurer) and Dr. C. G. Wynne (Honorary Secretary).

The Physical Society of London as it was then called was founded in 1874 and on the initiative of that Society's Council The Institute of Physics was founded 45 years later. The original scheme envisaged a kind of federation of societies interested in physics, to provide among other objects, rooms for meetings, a library, and a common secretariat. In fact the Institute's offices were in the Society's present rooms South Kensington from 1927 to 1949 and the Institute provided the secretariat for The Physical Society and The Optical Society which themselves amalgamated in 1931.

At the time of its establishment no one could have foreseen the spectacular growth and influence of physics in the modern world. Broadly speaking before the war the scientific meetings and publications of the Institute were confined to applied physics while those of the Society were concerned more with pure physics. As, however, the boundary between these two aspects became less definite there has been increasing overlap in the activities of the two bodies and in their membership. It is not, therefore, surprising that during the past 20 years proposals for the amalgamation of the two bodies have been made repeatedly and from time to time detailed proposals examined, until eventually a satisfactory solution was worked out.

The qualification for the award of Fellow of The Institute of Physics, Associate of The Institute of Physics, and Graduate of The Institute of Physics will remain unchanged and members of the new body holding these diplomas will also be Fellows of The Physical Society. Besides the three Institute of Physics' grades of membership of the new body there will also be the grade to be known as 'Fellow of The Physical Society'. All the Fellows of the old Society will be automatically transferred to this new grade but new candidates for election to the grade will be required to possess a degree or diploma in physics recognized by the Council, or to satisfy the Council that they have a sufficient knowledge of physics.

Provision has been made for other scientists and engineers to participate in the scientific and educational work of the new body. Activities relating to the practice of the profession as such, will be strictly confined to those possessing one of the Institute's diplomas.

The Executive Officers of the new body are *Secretary*, Dr. H. R. Lang; *Editor and Deputy Secretary*, Dr. A. C. Stickland; and *Deputy Secretary*, Mr. N. Clarke. The registered offices and headquarters are at 47 Belgrave Square, London, S.W.1, and for the present, offices will also be retained at 1 Lowther Gardens, South Kensington, London, S.W.7.

Paul Instrument Fund Grants

Awards of grants by the Paul Instrument Fund Committee have been made as follows:

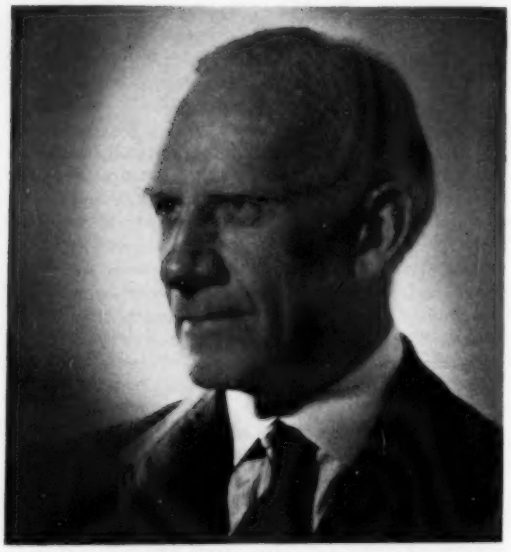
£2,500, with the probability of further grants totalling up to £3,000, to Dr. J. H. Sanders, university lecturer and demonstrator in physics, Clarendon Laboratory, Oxford, for the construction of an optical maser.

£3,000 to Mr. H. W. Gosling, lecturer in the department of engineering, University College of Swansea, for the construction of an instrument for checking the stability of the standard ampere.

CHEMISTRY

by

Sir Robert Robinson, O.M., M.A., D.Sc., Sc.D., LL.D., F.R.I.C., F.R.S.



Sir Robert Robinson, O.M., M.A., D.Sc., Sc.D., LL.D., F.R.I.C., F.R.S. *Courtesy Fayer.*

Throwing off the Shackles; Some Fundamental Discoveries

The Honourable Robert Boyle, the seventh son and fourteenth child of the Earl of Cork, was named by the Second Royal Charter as a Member of the Council (April 23, 1663). As a scientist he was certainly the most distinguished member of that Council and hence a tower of strength to the Society which he did so much to found and foster.

Boyle contributed reasoned scepticism in regard to the prevailing Aristotelian conception of four elements and the Paracelsian hypothesis of three principles. His voluminous writings led as much as anything to the overthrow of the Iatrochemists. His view of an element was pretty much that which held the field until the discovery of radioactivity, that is 'a body which cannot be further sub-divided and from which compounds can be made with other elements.'

He has well been called the 'Father of Chemistry' though his discoveries in the science were less remarkable than the clearing of the air in respect of theory. Chemistry became for the first time part of the Study of Nature. The mysticism surrounding the secret arts of the alchemist was banished, though remnants of the old attitude persisted for nearly a century. Boyle had clearer ideas about combustion than any of his predecessors and made constant use of an atomic theory in the sense of the Greek philosophers.

With the help of Robert Hooke, also an original Fellow, he constructed an improved air-pump with which he showed that Torricelli's mercury column was in fact sustained by the pressure of air, since it fell to near zero when the barometer was enclosed in a vessel and the air evacuated. One of his greatest contributions was the recognition of the 'Spring of Air' leading to his well-known Law. This he enunciated in the course of a reply to Franciscus Linus, who preferred to explain the barometer by the operation of an invisible cord that sustained the mercury.

Boyle's interests embraced everything he saw. He was the first to write of chemical analysis in terms which we could find acceptable and among other observations he noted the changes of colour of plant pigments on the addition of alkalis or acids.

Robert Hooke was happier than Boyle in his ideas of the nature of combustion. He was possibly the first to realize that fire and heat were produced by the interaction of the combustible with something in the air. His undoubted industry was like that of a bee, flitting from flower to flower.

John Mayow (1678), a medical practitioner, died a year after his election at the age of 35. But for this calamity he might well have discovered oxygen. He extended Hooke's observations, proved that the 'something in the air' combined with metals in their calcination, changed venous into arterial blood and was contained in saltpetre.

Another predecessor of Black, Priestley and Cavendish, as he was in one respect the successor of van Helmont (1577—1644), was Stephen Hales (1717)*, a clergyman who invented new devices for handling gases. For example, he heated coal, saltpetre, and red lead in a gun-barrel and collected the 'air' produced over water. With him 'air', an element, was a general

*Single dates in parentheses refer to the date of election as F.R.S.

term for all gases but he was well aware that 'airs' varied in quality. Thus he showed that exhaled 'air' could be made more suitable for re-inhalation by passing it over rags impregnated with caustic alkali solution. He knew too that plants are nourished by contact of their leaves with air. He was the first chemist to receive the Copley Medal (1739).

It is much to be regretted that Joseph Black (1728—1799) was never elected F.R.S., but it is perhaps permissible to remark that this Scotsman, born in France, became a Professor of Glasgow University and was one of the pioneers who paved the way for Lavoisier. Using the balance almost for the first time as an instrument of chemical research, he showed that caustic alkali (magnesia or lime) becomes mild alkali (magnesia alka or limestone), by union with fixed air (CO_2) and that this combination is reversed on calcination. It is small wonder that Black was one of the first of the phlogistonists to embrace the new doctrine of Lavoisier.

The Hon. Henry Cavendish (1731—1810; FRS 1760; Copley Medal 1766) was interested in many branches of science and devised an ingenious method for determining the density of the earth. However, more than half of his output of published papers was concerned with chemical topics. In 1766 he discovered hydrogen which he called 'inflammable air' and considered it to be the phlogiston of the metals. This 'inflammable air' was produced by dissolution of metals such as iron and zinc in diluted sulphuric or hydrochloric acids. When his contemporary, Priestley, discovered oxygen (de-phlogisticated air) Cavendish showed that water resulted from the union of two volumes of inflammable air and one of de-phlogisticated air.

This very significant discovery provided one of the foundations of Lavoisier's system but, although Cavendish clearly understood this, he remained a phlogistonist to the end. He followed up Black's work on fixed air by preparing the gas from marble chips and dilute hydrochloric acid; he determined the relative densities of 'fixed air' and 'inflammable air'. Cavendish was the first experimental chemist to achieve a really high standard of accuracy. (Doubtless he was assisted in this by his command of more than ample resources. Owing to his frugal, not to say eccentric habits, his fortune accumulated and on his death amounted to £1,300,000, worth much more then than now). An excellent example, also showing a new meticulosity of observation, was a side-issue of his synthesis (following an earlier observation by Priestley) of nitric acid by passing electric sparks through moist air. He was curious to find out whether the whole of the phlogisticated air (nitrogen) could be used up in this way. He found a residue of about 1/120th which no longer gave nitric acid on sparking with dephlogisticated air (oxygen). This inactive residue was doubtless argon mixed with other rare gases of the atmosphere.

Joseph Priestley (1733—1804; FRS 1766; Copley Medal 1772) made many experiments with 'airs' and the list of his discoveries is impressive: nitrous gas (NO_2), marine acid gas (HCl), alkaline air (NH_3), vitriolic acid gas (SO_2), fluor acid gas (HF) and, above all, dephlogisticated air (O_2).

In this remarkable discovery of oxygen, Priestley was anticipated by Scheele who, however, did not publish his work until three years later. Priestley's method was to heat mercuric oxide and he demonstrated the experiment to Lavoisier. As is usual in scientific progress, Priestley owed part of his success to a new technique. In his case it was the use of the mercurial trough for the collection of gases. By mixing marine acid gas with alkaline air, Priestley formed sal ammoniac (NH_4Cl).

The Hon. Robert Boyle.

Discovery or Isolation or Extended Study of Elements

Throughout its history, Fellows of the Royal Society have been prominent in these fields of discovery. It is not possible to mention all such studies and only a brief selection follows:

Sir Humphrey Davy (1778—1820; FRS 1803; Copley Medal 1805) may justly be regarded as the first great chemist of the new era. A first discovery, that of laughing gas (N_2O), had a popular success and may have had some influence in bringing about Davy's election to the Professorship of Chemistry at the newly founded Royal Institution (1801). Here, with a well-equipped laboratory, he studied the construction of voltaic cells and the phenomena of electrolysis. He showed for the first time that pure water electrolyzed in gold vessels afforded only hydrogen and oxygen; the acid and alkali which Nicholson and Carlisle had obtained was derived from impurities. Davy reproduced the phenomena by electrolyzing solutions of salts.

This led him to the isolation of potassium by passing

Sir Humphrey Davy.

the current from the most powerful battery so far constructed through fused potassium hydroxide. Later, as 'Poy' of 'Vanity Fair' put it, 'he incurred the odium of discovering sodium.' The alkaline earth metals followed with more difficulty. Berzelius contributed the useful suggestion that they might be obtained in the first place as amalgams (anticipation of the Castner-Kellner process!) and in this way magnesium, calcium, strontium, barium and lithium were obtained in the free state.

Davy's proofs of the elementary nature of chlorine established a very important point of theory and disproved Lavoisier's oxygen-acid hypothesis. Davy, after some hesitating steps, proclaimed that hydrogen and not oxygen was the essential constituent of all acids. Due to the prestige of Lavoisier most contemporary chemists accepted Davy's view that some acids do not contain oxygen but a distinction was drawn between those that conform to Lavoisier's generalization and the new class of hydracids, for example hydriodic acid and hydrocyanic acid.

William Hyde Wollaston (1766—1828; FRS 1793; Copley Medal 1802) made a penetrating study of the metals of the platinum group and devised a novel method for handling that metal and fabricating articles from it. He discovered palladium, rhodium, niobium and titanium. (Smithson Tennant (1785) discovered two other metals of the platinum group, namely osmium and iridium, in 1804). He greatly improved the goniometer and invented the *camera lucida*. His contribution to chemical philosophy was the conception of the 'equivalent' which was based on accurate chemical analysis. Wollaston was sceptical of Dalton's atomic theory and yet his equivalents were related to the atomic weights, though certainly unintentionally so.

Sir William Crookes (1863; Copley Medal 1904) and Sir Henry E. Roscoe (1863) are in the middle period. The former studied compounds of selenium and discovered thallium; the latter carried out extensive researches on the compounds of vanadium, among other contributions. A pioneering Professor at Owens College, Manchester, he gave yeoman service to chemical education and raised the esteem in which science in general, and chemistry in particular, was held by the public.

Doubtless it is a considerable jump to Sir William Ramsay (1888), but as already seen the story of the rare gases of the atmosphere started with Cavendish. It was continued by the first Lord Rayleigh (1873; Copley Medal 1899) who found in 1894 that nitrogen obtained from the atmosphere was 0·5 per cent heavier than the gas obtained from its compounds. Working on a larger scale Ramsay and Rayleigh purified the inert gas, argon. In 1898 Ramsay and M. W. Travers (1904) separated, from the same source, neon, xenon and krypton.

The prominent yellow line in the solar (chromosphere) spectrum, first noticed by Jansen in 1868 and attributed to a hitherto unknown element termed helium, was further confirmed by Frankland and Lockyer and in 1882 Palmieri noted the helium line in material from the vicinity of Vesuvius. In 1895 Ramsay

Sir William Ramsay.

John Dalton

and Travers obtained helium from the mineral cleveite—truly a dramatic episode. Much later the radium emanation (see below) added a new heavier term to the series.

Development of Theoretical Chemistry in the XIXth Century

John Dalton (1766—1844; FRS 1822) did not originate the physical atomic theory and stated quite clearly that 'the conclusion seems universally adopted that all bodies of sensible magnitude, whether liquid or solid, are constituted of a vast number of extremely small particles . . . .' And there is undoubtedly some substance in the claim made by William Higgins (1806) in 1814 that he had employed a chemical atomic theory as far back as 1789. Nevertheless the credit for a clear statement of the chemical atomic and molecular theory must be conceded to Dalton, who understood and explained lucidly examples of the law of multiple proportions; developed the conceptions of relative atomic weights, and in fact originated the idea of molecular structure.

It makes no difference that this idea saw the light in a rudimentary form, or that many mistakes were made in its applications. As an example, Dalton found that ethylene contains 5·4 parts of carbon for 1 part of hydrogen and marsh gas contains 5·4 parts of carbon for 2 parts of hydrogen. He made the simplest assumption possible, namely that ethylene is CH and marsh gas CH_2 and the atomic weight of carbon was given as 5·4. Analyses were not yet very accurate. The theory was widely accepted but its arbitrary nature and the inconsistencies which emerged were criticized. For example Wollaston proposed to replace the atomic hypothesis by that of the equivalent, basing this suggestion on much earlier work of Richter and on his own work on the carbonates and that of Thomas Thomson (1811) on the oxalates. These elegant investigations on simple dibasic acids came to be regarded as foundations of the atomic theory although this was far from being Wollaston's intention.

The battle was already won when Thomas Graham (1836; Copley Medal 1862) published in 1833 his brilliant 'Researches on the arseniates, phosphates, etc.' adding examples of tribasic acids forming salts with one, two, or three atoms, or equivalents of base. Graham says that phosphoric acid combines with three atoms of water and that these may be replaced wholly or in part by atoms of base (water was also considered a base).

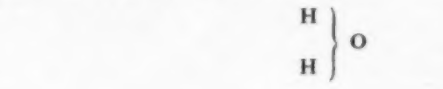
The fact is that Wollaston's equivalents were simply the proportions in which substances combine. He made no attempt to incorporate multiple proportions. As chemistry advanced it was seen that the apparent failures of the atomic theory were due to too great expectations and that molecules could be much more complex than was at first contemplated.

It became an objective of the first importance to determine the true atomic weights and the atomic composition of molecules. A system was finally agreed shortly after the middle of the century and in the development of it the names of Berzelius, Avogadro, Dulong and Petit, Dumas, Gerhardt and Laurent, Bunsen, Liebig and Wöhler and Cannizzaro are among those most honoured. Many of these were Foreign Members of the Royal Society. An Englishman, however, contributed a crucial set of experiments which went far to clarify the issues. The dubiety he resolved was that concerning the relation between alcohol and ether. Using modern atomic weights, one school of thought considered alcohol to be $C_4H_{12}O_2$ which, less H_2O, gave ether, $C_4H_{10}O$. The other view was

Michael Faraday.

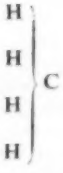
that alcohol is C_2H_6O, two molcules of which less H_2O, afforded ether, $C_4H_{10}O$.

Alexander W. Williamson (1855) made new syntheses of various ethers, the more useful of which was RONa + Rhal ⟶ ROR. Using RONa and R′ hal, he obtained mixed ethers. In this way he not only cleared up the matter in hand but inaugurated the era of resort to synthesis as a tool in structural enquiries. Thus was established the water type,

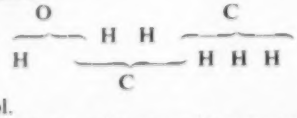


A. W. Hofmann (1851) added the ammonia type

and Kekulé the marsh gas type



This was perhaps foreshadowed by Williamson in 1854 when he prepared tribasic formic ether $(CH(OEt)_3)$ by heating chloroform with sodium ethoxide; actually the substance was formulated on the basis of three condensed molecules of water. Eventually the mixed types were formulated (Williamson, Gerhardt, W. Odling (1859)) such as



for alcohol.

The transition to the presently accepted structural formulae was a natural one and involved little more in principle than a more convenient symbolism. The way was open to the erection of the system of organic chemistry.

Another rather natural growth (or so it now seems to us) was the doctrine of atomicity (valency) which was proposed by E. Frankland (1853; Copley Medal 1894). Frankland's own researches in this and other fields were masterly; he was a pioneer in the exploration of organo-metallic compounds such as zinc ethyl, a consideration of which helped to extend and promote his theoretical views.

We cannot claim all the credit for Williamson and Frankland but these two Fellows of the Royal Society laid two of the foundation stones on which the imposing edifice of organic chemistry was constructed in the succeeding hundred years.

Side by side with performance of analysis and synthesis, chemists strove to understand the mechanism of chemical transformations. The major contributions came from abroad but A. Lapworth (1910) was a British pioneer in the field and his work on the course of the bromination of acetone and on that of the benzoin synthesis have justly been regarded as milestones of progress. Again in the later developments of valency theory, Lennard-Jones (1933) was prominent among mathematicians who strove to clarify the nature of the chemical bond in terms of wave mechanics. In 1929 he explained the paramagnetism of oxygen on a theoretical basis.

Descriptive Chemistry, New Compounds, Methods, and Study of Natural Products

Under this heading only a few selections can be made. Sir Benjamin Brodie (1810; Copley Medal 1811) studied the reactions of ozone and demonstrated that the gas has the formula O_3. Michael Faraday (1824; Copley Medal 1832 and 1838, a unique double award), in addition to his electrochemical work, pursued purely chemical topics, for example he discovered benzene. Sir William Perkin (1866) enriched organic chemistry in many directions. He synthesized coumarin and cinnamic acid. His elder son W. H. Perkin (1890) was one of the most prolific investigators of his time. He is especially well known for his syntheses of carbocyclic compounds and of some simpler terpenes, and also for his degradative work on berberine and brazilin. A. G. Perkin (1903) pioneered the study of plant pigments of the flavone class. He was one of the first to make a survey of plant products, based in his case on a chemical rather than a botanical classification. P. Griess (1868) discovered the process of diazotization, a method of great value in synthesis and of vital importance for the fabrication of dyestuffs.

C. Schorlemmer (1871) devoted himself to the development of the aliphatic series and was the first historian of organic chemistry.

H. E. Armstrong (1876) made noteworthy studies of the derivatives of naphthalene, largely in collaboration with W. P. Wynne (1896). If these researches had been exploited energetically in this country, the course of the dyestuffs industry might have been different.

A. G. Green (1915) discovered primuline and was one of the few who followed Sir William Perkin's lead.

W. A. Tilden (1880) examined isoprene found by the distillation of caoutchouc and noted its polymerization with reformation of a rubbery substance.

J. N. Collie (1896) discovered the basic properties of dimethylpyrone and thus founded the oxonium theory. He made many observations on ring-closure of polyketo-methylenes and was led to formulate theoretical schemes of biogenesis, some of which have come to life in modern dress.

J. Purdie (1895), Sir James Irvine (1918) and Sir Norman Haworth (1928) successively developed the St. Andrew's and Birmingham schools of carbohydrate chemistry. The subject was transformed and precision was introduced over the whole structural field, including even the polysaccharides. The possibility of such development stemmed from the invention of the Purdie-Irvine method for methylating the hydroxyl groups and its full realization was due to the truly colossal industry of Haworth and his numerous collaborators. A rule must be broken here because of the great part played in these researches by E. L. Hirst (1934).

An experiment in the carbohydrate field which is fascinating on account of its simplicity was performed by E. F. Armstrong (1920). The isomeric methyl glucosides were related stereochemically to the glucoses by enzymic hydrolysis and observation of accelerated muntarotation.

Among many others, mention must be made of Sir Frederick Hopkins (1905; Copley Medal 1926) because of his discovery of tryptophan; of Sir Jocelyn Thorpe (1908) for his elegant researches on the synthesis of carbocyclic compounds; of G. Barger (1919) on account of his work on physiologically active amines and on alkaloids; of F. L. Pyman (1922) for his synthesis of histidine; of Sir Ian Heilbron (1931) for pioneer work on vitamin-A, ergosterol, and general synthetic organic chemistry; of Sir John Simonsen (1932) for his discovery of the carenes and many other studies in the terpene series; and of W. H. Mills (1923) for his brilliant work in stereochemistry. Sir William J. Pope (1902) and S. Smiles (1918) were also pioneers in the stereochemical field, especially in extending the scope of the asymmetric atom to elements other than carbon. Pope and H. E. Armstrong understood the importance for theoretical chemistry of the intimate study of crystals but were too early. The appropriate tool of x-ray diffraction was unfortunately not available for them.

Electrochemistry, Radioactivity and Isotopes

Humphrey Davy was the first to suggest that chemical affinity is a manifestation of electrical attraction. He noted that copper was positively charged when in contact with sulphur and that the charge increased on raising the temperature. If the two substances were heated sufficiently they united with evolution of heat. The latter arose according to Davy from the neutralization of the electrical charges in a display of the operation of chemical affinity. Ideas of this kind encouraged him to perform his experiments on electrolysis, the outcome of which in its turn confirmed him in his beliefs. Nevertheless, Davy never attempted to construct a consistent system on this electrochemical basis and it was left to Berzelius to propound his dualistic theory in a form which was found widely acceptable, apart from exaggerations on which attacks were later focused.

Faraday gave strong support to the electrochemical theory by enunciating his law connecting the amount of chemical change with the quantity of electricity used to produce it. In his voltameter he applied this principle to the measurement of current by estimating the volume of gas produced in electrolysis. It is of interest that G. Johnstone Stoney (1861) (who introduced the term 'electron') and also Helmholtz concluded from a consideration of Faraday's Law of Electrolysis that electricity occurs in unit quantities; that is, it has an atomic constitution.

In 1897 Sir Joseph Thomson demonstrated the existence of the electron and determined its mass and charge. The subject is in the domain of physics, as is the entire topic of the structure of the atom. Nevertheless the chemical implications are of great significance and Thomson himself drew attention to many of these in his Silliman Lectures.

Following the discovery of radium, Ernest Rutherford, afterwards Lord Rutherford of Nelson (1903; Copley Medal 1922), made a study of radioactive substances from every point of view. In 1902 Rutherford and Frederick Soddy (1910) advanced their theory of atomic disintegration. Although the ramifying developments have been made by physicists, it may be that Soddy's experience as a physical chemist enabled him to recognize in the observed course of radioactive decay the evidence of a monatomic process. In collaboration with Ramsay he studied the radium emanation (niton) and showed that it behaved as a true gas obeying Boyle's Law and being capable of liquefaction and solidification. The same chemists proved that helium is produced when niton is kept for a few days.

As a result of his work on the products of decomposition of radioactive substances, Soddy was led to enunciate his hypothesis of isotopes. Precedently, Henry G. J. Moseley, from a study of the x-ray spectra of the elements, was able to arrange them in a consecutive series of atomic numbers, identified with the charge on the nucleus. Soddy pointed out that elements

Prof. F. Soddy.

of the same atomic number but different mass could exist and these he termed isotopes. Using a mass spectrograph which he had designed, Sir Joseph Thomson demonstrated the existence of an isotope of neon and later F. W. Aston (1921), with an improved instrument based on the same principle, discovered isotopes of many elements as the result of a wide survey.

Subsequently Urey separated deuterium oxide (heavy water, D_2O; D having relative mass 2). Tritium oxide (tritium having mass 3), of which the hydrogen isotope is radioactive, was found as a product of decomposition of radioactive material. Carbon of mass 14 is formed in the atmosphere as the result of the action of cosmic rays on nitrogen; it is also radioactive.

These and other isotopes (of O, N, S, P, etc.) have proved of inestimable value as tracers, a use first suggested by G. Hevesey. With the aid of the radioactive C^{14}, for example, it has proved possible to follow the course of the biogenesis of many plant products. Incidentally, it has also been used to date objects of antiquarian interest, provided they are partly or wholly composed of wood, and their age does not much exceed 7-8,000 years.

A whole new chemistry of the radioactive elements has sprung up and is of surpassing importance, but the methods of investigation are physical rather than chemical and no attempt can be made here to cover even the outlines of the subject.

Some Physico-chemical Studies

Several matters under this head have already been mentioned. Faraday was the first to liquefy certain gases and Sir James Dewar (1879; Copley Medal 1916) later condensed the more refractory so-called permanent gases. He prepared liquid oxygen and ozone and examined their magnetic properties. Graham did pioneer work on gaseous diffusion while F. G. Donnan (1911) is best known for his studies of membrane equilibria.

Sir William Bragg (1907; Copley Medal 1930) was the most effective disciple of Lane and by his enthusiasm and personal contributions became one of the founders of chemical x-ray crystallography. In this field, as in many others, it is a handicap to avoid the mention of living persons. So much of the growth of this subject has occurred during the last 20 years.

A Few Matters of Industrial Interest

The Fellows of the Royal Society have been primarily interested in the promotion of pure science but have also made most significant contributions to industry, often as a result of fundamental research. The following short list merely indicates the type of such advances; it is by no means complete.

Sir Frederick Abel (1860) is renowned for his improvements in the manufacture of industrial explosives. H. B. Dixon (1886) photographed the explosive wave in gases and made fundamental contributions to the study of the mechanism of gaseous reactions. Though somewhat out of place, the opportunity must be taken to mention the work of H. B. Baker (1902) in the non-occurrence of reactions in carefully dried gases. Dixon's work has a direct industrial interest in relation to safety in mines and was continued and extended by W. A. Bone (1905), R. V. Wheeler and Sir Alfred Egerton (1926). Both Bone and Egerton also worked in other directions and made contributions to our understanding of the mechanism of combustion.

The process for the manufacture of steel due to Sir Henry Bessemer (1879) revolutionized the industry. C. F. Cross (1917), by his discovery of viscose, founded an expanding development in the manufacture of textiles. The discovery of the formation and decomposition of nickel carbonyl led Ludwig Mond (1891) to a convenient process for the extraction of nickel. The scientific work of Sir Harold C. H. Carpenter (1918) and C. H. Desch (1923) was also of great value in metallurgical technology. Similarly the study of distillation by S. Young (1893) was of value in many industries, of which that of the refining of petroleum was probably the chief.

The discovery of mauveine by Sir William H. Perkin (1866), when only 17 years of age, was a dramatic event, surpassed however by the amazing energy with which he exploited it. The claim made for Perkin that he founded the organic chemical industry is valid for synthetical operations, which had not previously been undertaken on a large scale.

The writer is conscious of the gaps in the above sketch of chemical work by Fellows of the Royal Society. With one exception, living scientists have not been mentioned and matters usually developed with the aid of physical or biochemical techniques have also been excluded.

The contributions of Foreign Members have necessarily been passed over.

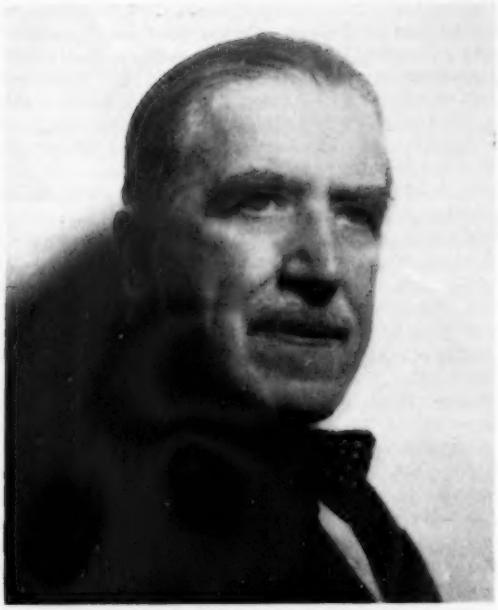
Most of the great chemists were Foreign Members and to include their work would have involved writing a History of Chemistry as such, without any clear special relation to the Royal Society.

Forest Products Research Laboratory

The new Director of the Forest Products Research Laboratory will be Mr. A. C. Copisarow, at present Scientific Attaché at Paris, instead of Mr. H. Wooldridge, O.B.E. Mr. Wooldridge has agreed to withdraw his acceptance of the Directorship of Forest Products Research at the special request of the Secretary of the Department. This was made because of the increasing pressure of work at Headquarters, D.S.I.R. Mr. Wooldridge will continue to hold the post of Deputy Director, Stations Division.

Mr. Copisarow will take up his post at the Forest Products Research Laboratory on promotion in October when Dr. F. Y. Henderson, C.B.E., the present Director, retires.

Mr. Copisarow graduated in 1942 in the Honours School of Geology at the University of Manchester. He served as Lieutenant, Royal Navy, for four years on radar duties, and from 1946 to 1954 was with the Joint Intelligence Bureau of the Ministry of Defence, publishing also a series of fundamental papers in colloidal chemistry. A former Council of Europe Research Fellow, he has served at the British Embassy in Paris for six years. He is married and has two daughters.



Dr. E. Hindle, M.A., Sc.D., Ph.D., F.R.S.

BIOLOGY

by

Edward Hindle, M.A., Sc.D., Ph.D., F.R.S.

Introduction

The declared object of The Royal Society at its foundation was the promotion of natural knowledge by observation and experiment, and in the early years of its history sciences promoted by experiment occupied a prominent position. Also one of the more important functions of the Society was the performance of experiments before the members, and for this purpose it had the power of appointing two 'curators of experiments'. The first of these, the famous Robert Hooke, afterwards Secretary, displayed remarkable ingenuity in devising programmes of experiments which were exhibited at every meeting. Among these early exhibits one of the most important, from a biological point of view, was the first effective compound microscope. Hooke's *Micrographia*, published in 1665, opens with a description of this microscope and then proceeds to give a number of observations made with its aid, illustrated by remarkably accurate and beautiful figures. He showed the microscopic structure of cork, and referred to the walls as *cells*. He also gave a good account of the cells on the surface of a stinging-nettle leaf and the stinging apparatus, and other botanical records. His zoological work includes the first illustration of a Polyzoon, and drawings of many classical subjects of microscopy, such as the markings on fish scales, the structure of the bee's sting, the foot of the house-fly, the radulae of molluscs, and structure of feathers. His figures of minute insects, spiders and mites, and especially of a gnat and its larva, a flea (Fig. 1) and a louse, have never been surpassed. Another great microscopist, Nehemiah Grew (1641-1712), who became Secretary of the Society in 1677, took up the study of plant anatomy and in his *Anatomy of Plants* (London, 1682) recognized their cellular nature. He also advanced the view that flowers are the sexual organs of plants and in discourse with Sir Thomas Millington, the Sedleian Professor, conceived the idea that the anthers acted as male for the generation of seed.

The New Philosophy

The work of the early microscopists opened up a new world but for the most part their observations remained somewhat disconnected, accumulations of facts rather than natural science, and awaited the growth of a new philosophy in the study of nature. This was growing up during the seventeenth century, but until the time of John Ray (1627-1705) zoology remained entangled with 'Hieroglyphics, Emblems, Morals, Fables, Presages, or ought else appertaining to Divinity, Ethics, Grammar or any sort of Humane Learning'. John Ray (born Wray), the son of a blacksmith at Black Notley, succeeded in obtaining a scholarship to Cambridge where he became a close friend of Francis Willughby, a leading naturalist and founder member of The Royal Society. The two decided to prepare a systematic description of the whole organic world; Willughby would finance the venture and describe the animals, and Ray the plants. They undertook various journeys together, including one of three years to France, Holland, Germany, Switzerland, Italy and Malta. The result was a very great increase in the botanical and

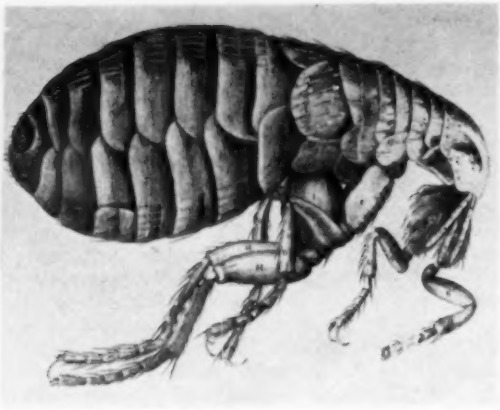
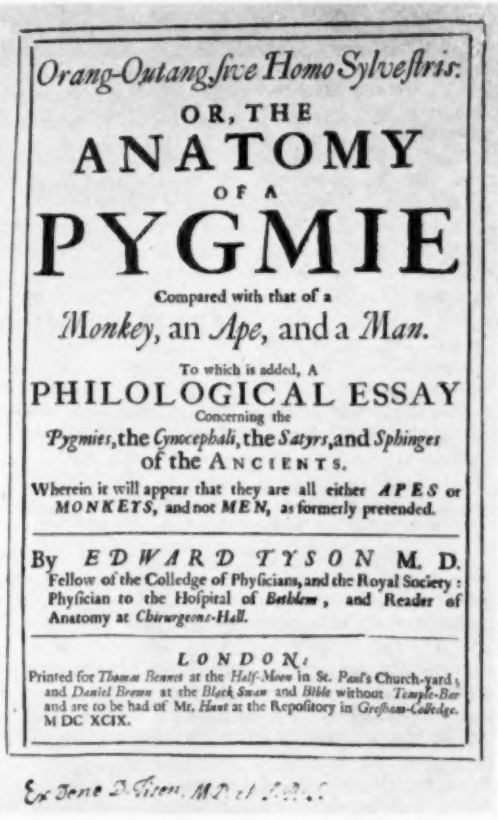


Fig. 1. The flea from Hooke's *Micrographia*.

zoological knowledge of Europe, incorporated in a series of monographs. Willughby died at the age of 37 years and had only completed part of his task but he left an annuity to Ray who edited his book on Fishes, published by The Royal Society. Ray's most important work, however, was an attempt to arrange all known plants under his system of classification based on the fruit, coupled with leaf and flower. This immense task was executed in three large folio volumes, *Historia Plantarum Generalis*, which contains an account of 18,600 plants. He also devised a system of classification for animals far in advance of any preceding method. His zoological publications include his *Synopsis Quadrupedum*, *Synopsis Avium et Piscium*, *Methodus Insectorum*, as well as his joint works with Willughby. Ray's method of classification was superseded later by the simpler Linnaean system, but it helped to establish some kind of order in the descriptions of animals and plants, and his idea of the biological status of a species was much more modern than that of Linnaeus a century later, for he did not accept the fixity of species as a dogma. He also recognized the sexual nature of flowers. He took the first step in a 'natural system' of classification in which all resemblances are taken into account and not only a few artificially selected characters. Many of his larger groupings of plants, now called Natural Orders, are still recognized. He divided flowering plants into Dicotyledons and Monocotyledons and among other contributions set forth the true nature of fossils as petrified remains of extinct species.

Medical Interests

The development of a system of classification and an expanding knowledge of the animal and vegetable world was accompanied by a wider interest in human and comparative anatomy, probably stimulated by William Harvey's great work on blood circulation published in 1628. Various anatomists figure among the founders and early Fellows of the Society. Francis Glisson (1597-1677), one of the founders, published two works, one on the liver, and the other on the stomach and intestines. He distinguishes matter out of which something is produced, from form, the change in matter which serves a given purpose. He believed that evacuation of the gall bladder was the result of nervous irritability and understood the function of the lacteals. Thomas Wharton (1614-1673), a physician and early Fellow of the Society, is famous for his work *Adenographia*, the first comparative account of the glands of the body; and Thomas Willis (1621-1675) described the anatomy of the human brain and cranial nerves and also studied the nervous system of various animals including the oyster, lobster and earthworm. George Ent (1604-1689), a friend and supporter of Harvey, wrote a memoir on the anatomy of fishes, *Lophius*, *Galeus* and *Raia*. Allen Molines (or Moulin) who died in 1690, and Patrick Blair (d.1728) published descriptions of the anatomy of the elephant and Edward Browne (1644-1708) was the first to dissect an ostrich. Edward Tyson (1650-1708) (Fig. 2) wrote a descriptive anatomy of selected types including a young chimpanzee, a female



Orang-Outang sive Homo Sylvestris:

OR, THE

ANATOMY

OF A

PYGMIE

Compared with that of a

Monkey, an *Ape*, and a *Man*.

To which is added, A

PHILOLOGICAL ESSAY

Concerning the

Pygmies, the *Cynocephali*, the *Satyrs*, and *Sphinges* of the ANCIENTS.

Wherein it will appear that they are all either *APES* or *MONKEYS*, and not *MEN*, as formerly pretended.

By *EDWARD TYSON* M. D.

Fellow of the Colledge of Physicians, and the Royal Society: Physician to the Hospital of *Bethlem*, and Reader of Anatomy at *Chirurgeons-Hall*.

LONDON:

Printed for *Thomas Bennet* at the *Half-Moon* in St. *Paul's* Church-yard; and *Daniel Brown* at the *Black Swan* and *Bible* without *Temple-Bar* and are to be had of Mr. *Hunt* at the Repository in *Gresham-College*. MDC XCIX.

Fig. 2. Frontispiece of Edward Tyson's book.

porpoise, a Virginia opossum, a rattlesnake, *Ascaris* and a tapeworm, and distinguished the sexes of *Ascaris*. He made a comparative survey of the parts of the body and how the animal machine is built up, and even attempted an examination of its more fluid constituents. His collections were deposited in the British Museum and Royal College of Physicians.

Museums

The further development of microscopy was delayed by the limitations of the early compound microscopes but the work of Ray and other naturalists, and also the early anatomists, was continued and extended throughout the eighteenth century. One of the results was the collection of animals and plants from all parts of the world and the establishment of museums. The first scientific museum of any educational value in England was established by The Royal Society early in its history and catalogued by Grew. (Fig. 3.)

As one of the early activities of the Society, Fellows were asked to suggest subjects for research and to develop their theses practically at meetings to be convened for that purpose. At a meeting of the Society on May 28, 1662, 'Mr. Croune produced two embryos of puppy dogs which he had kept eight days, and were put in spirits of wine in a glass-vial sealed hermetically'. This seems to be the first record of the use of alcohol as a preservative of animal tissues and opened the possibility of showing material not capable of being preserved in a dried state. Robert Boyle (1627-1691), in 1663, recommended the same fluid for the preservation of human bodies and the following year showed a linnet and a snake which had been preserved in spirits of wine for four months. Also the dissection of a human foetus preserved in the same fashion was demonstrated to the Society by Edmund King (1629-1709) in 1666. These various collections, including many scientific instruments, were transferred to the British Museum in 1781 but most of the specimens seem to have disappeared. Hans Sloane's (1660-1753) collections formed the nucleus of the British Museum, which rapidly expanded after its foundation in 1759.

One of the most famous collectors of the century was Joseph Banks (1743-1820) who accompanied Cook in the *Endeavour* and provided equipment for the conduct of biological work during the voyage. Banks made various other expeditions and together with his staff greatly increased the knowledge of plants, birds and fish in various parts of the world. He was President of The Royal Society for the record period of 42 years, and among his many activities was mainly responsible for the foundation of Kew Gardens. (*See* illustration on p. 497).

Anatomy

Comparative anatomy in the eighteenth century is distinguished by the work of John Hunter (1728-93) who anatomized over 500 species of animals, also many plants, and built up an enormous collection which was bought by the Royal College of Surgeons in London, and forms the nucleus of the Hunterian Museum. Hunter was one of the most remarkable biologists of that century. Apart from his famous anatomical work, he was far in advance of his contemporaries in attempting to correlate form and function. He considered life to be independent of structure in the various activities of living beings. He attempted to trace systematically, both in animals and plants, the different phases of life exhibited by the organs and structures. He was interested in monstrosities and their production and made many experiments on the temperature of plants and of animals. He was a pioneer in the study of animal behaviour and in connection with this subject made important investigations on bees.

The development of physiology was delayed by the imperfect knowledge of chemistry and physics but reference should be made to the remarkable work of Stephen Hales (1677-1761) on the physiology of plants and animals, the most important work on this subject until the nineteenth century. Some of his botanical experiments on transpiration and kindred subjects,

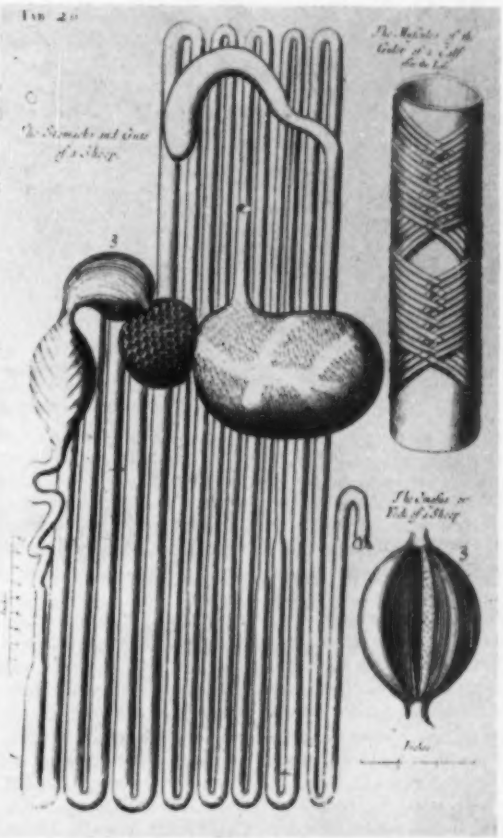


Fig. 3. Stomach and intestines of sheep, etc., from Grew's work.

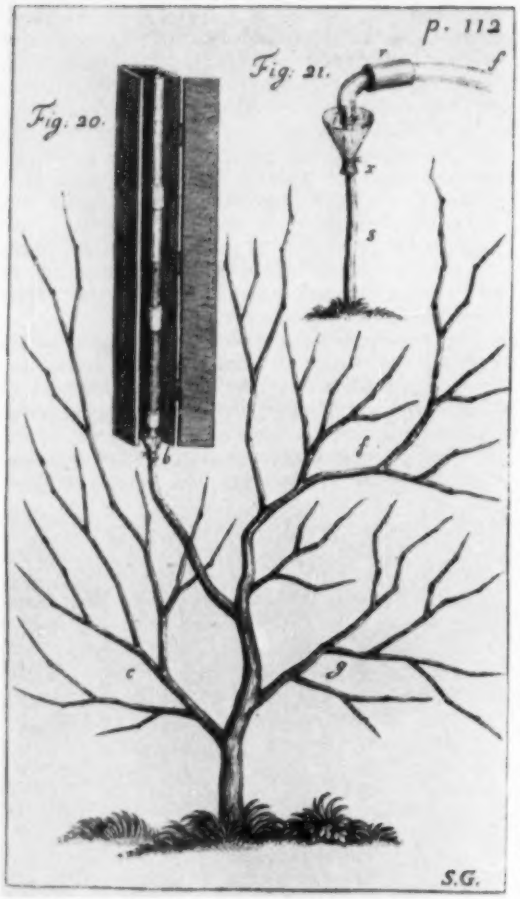


Fig. 4. From *Vegetable Staticks* by Stephen Hales showing rise of sap in stem of vine.

described in *Vegetable Staticks* (London, 1727), are still in use (Fig. 4). He also did pioneer work in animal physiology with his studies of blood pressure. Reference should also be made to the work of T. A. Knight (1759-1838) on tropisms and the reactions of plants to light, gravity, etc.

Scientific Expeditions

During the nineteenth century scientific expeditions continued to be sent to various parts of the world and were usually accompanied by distinguished naturalists. Among these mention may be made of the following, in which the name of the ship precedes that of the naturalist:—*Beagle* (1831-36) with Charles Darwin; *Erebus and Terror* (1839-43), Joseph Hooker; *Rattlesnake* (1846-50), T. H. Huxley; *Lightening* (1868), Wyville Thomson and W. B. Carpenter; *Porcupine* (1869-70), Wyville Thomson, Carpenter and Gwyn Jeffries; and especially *Challenger* (1872-76), Wyville Thomson and others.

These exploratory voyages resulted in greatly increased knowledge of the distribution of animals and plants. Darwin, in the voyage of the *Beagle* in particular brought to light many striking facts, especially the very peculiar animals and plants associated with oceanic islands, and his studies on the Galapagos Islands were of especial importance in the development of his theory of evolution. The first attempt to divide the world into zoological regions was made by P. L. Sclater (1829-1913) based on the distribution of birds. A. R. Wallace (1823-1913) in Malaya developed the subject with special reference to mammals and his *Geographical Distribution of Animals* published in 1876 still remains the most important account of the way the land surface of the earth can be divided into zoo-geographical areas. Edward Forbes (1815-1854), one of the fore-runners of the theory of evolution, called attention to specific and generic centres of distribution and the migration of species in space and time, and also promoted the study of oceanography after becoming professor of natural history at Edinburgh University. His successor in the Chair, Wyville Thomson (1830-1882) was in charge of the staff of six naturalists carried on the *Challenger* (1872-76) the most ambitious scheme of marine biological investigation ever attempted. The vast collections accumulated on the voyage were investigated by experts in each group under the direction of John Murray (1841-1914). The account of this expedition in 50 large folio volumes provided a basis for the development of oceanography, which although fundamentally biological in its inception has rapidly expanded into a new branch of science.

General Biology and Physiology

In the first half of the nineteenth century biologists were mainly concerned with establishing affinities between different types of living beings and a series of monographs were produced on various groups of animals and plants. C. Darwin's monograph on the *Cirripedia* is an outstanding example of this kind of work and many of the leading zoologists and botanists did taxonomic work at some time in their careers. The structure of contrasted forms was investigated by the morphologists, or comparative anatomists, the most famous in the animal world being Richard Owen (1804-92) who was also the leading palaeontologist and first Director of the British Museum (Natural History). In the field of botany Robert Brown (1773-1858), naturalist on the Matthew Flinders expedition to Australia and Tasmania (1801-1805) produced a long series of important and original works. Joseph Banks left to Brown his house in London together with his library and collections which afterwards passed to the British Museum. In addition to taxonomic work Brown recognized the cell nucleus, the nature of the sexual process in the higher plants and made microscopical examinations of fossil plants. His name is familiar to all microscopists for he was the first to describe the dancing movements of minute particles suspended in liquids, known as 'Brownian movement'.

W. C. Williamson (1816-95) carried on the study of fossil plants, and demonstrated the nature of several of the larger groups, especially the gigantic woody forms found in the coal measures. There was also a great extension in the scientific study of animal function by means of physical and chemical experiments which had begun to develop. Most of these studies were made by medical men interested in practical applications, and physiology down to the end of the nineteenth century is mainly concerned with the higher vertebrates especially those nearest to man. Charles Bell (1774-1842) worked on the double spinal roots of the segmental nerves of the body and showed that one root conveys only sensory impulses and the other root only motor impulses. Another distinguished physiologist, Marshall Hall (1790-1857), working mainly with cold blooded vertebrates, showed the presence in the spinal cord of nervous centres for many reflexes. David Ferrier (1843-1928) demonstrated the functional differentiation of areas of the brain cortex other than those which evoke muscular activity and the investigation of nervous integration was carried out especially by Charles Sherrington (1861-1954). However, many of the greatest discoveries in physiology and the extension of the subject from the study of vertebrates, especially mammals, to invertebrates have taken place since 1900.

Tropical Medicine

One branch in which British biologists have been pre-eminent is the field of tropical medicine. Patrick Manson's (1844-1922) (Fig. 5) discovery in 1878 that mosquitoes were responsible for the transmission of filariasis, is one of the landmarks in the history of the subject. This first demonstration that blood sucking insects might transmit infection was followed by the remarkable work of Ronald Ross (1857-1932) on the development of *Proteosoma* and the manner in which is is spread by mosquitoes which placed the control of malaria on a scientific basis. Incidentally it is often not generally realized that malaria is still the greatest single cause of death and sickness to mankind. In 1895 David Bruce (1855-1931) elucidated the aetiology of Nagana, a cattle disease caused by the presence of a trypanosome in the blood, which is transmitted by certain species of tsetse-flies, especially *Glossina morsitans*. Later he extended this work to a similar infection in man, Sleeping Sickness, caused by *Trypanosoma gambiense*, transmitted by *Glossina palpalis*. It is doubtful whether any single event has ever had such far-reaching consequences on the health of the world as the discoveries resulting from Manson's original paper which have led the way to methods of control for such important diseases as malaria, yellow fever, trypanosomiasis, relapsing fever, filariasis, dengue, leishmaniases, pappataci fever, bubonic plague and many others, all transmitted by biting-flies, or other arthropods. These developments, however, have taken place for the most part during the present century.

Fig. 5. Sir Patrick Manson – Father of Tropical Medicine.

Evolution

The greatest event in the history of biology is undoubtedly the first public statement of the theory of evolution by natural selection made by Charles Darwin (1809-1882) and Alfred Russel Wallace before a meeting of the Linnaean Society of London on July 1, 1858, for here was a general principle capable of universal application throughout the realm of living beings. Darwin's *Origin of Species*, published the following year, presented the evidence in such convincing fashion that with few exceptions biologists very soon accepted this theory of evolution, and its ideas have provided the main stimulus for biological research down to the present time. The theory led to an increased interest not only in taxonomy but also in geographical distribution, variation, heredity, embryology and other fields of biology.

The study of variation received a great impetus by the work of William Bateson (1861-1926), who also took an active part in the rediscovery of Mendel's theory of inheritance at the end of the century. Previously Francis Galton (1822-1911) had developed the statistical treatment of biological material and introduced his 'Law of Ancestral Inheritance' based on the proportionate contribution by each generation of ancestors to the make-up of the individual. His work was continued and extended by Karl Pearson (1857-1936) and led to the formation of the branch of biology known as Biometrics. The knowledge of embryology was advanced especially by F. M. Balfour (1851-52) who is generally recognized as the founder of the modern study of systematic evolutionary embryology.

His work was developed and expounded by E. Ray Lankester (1847-1929), after T. H. Huxley (1825-95) the greatest English teacher of biology of the nineteenth century. Huxley is also famous for his important contributions to the study of embryology, comparative anatomy and classification, and took a leading part in defending Darwin's theory of evolution. Charles Darwin, Huxley, and Lankester are outstanding examples of the age of non-specialization when it was still possible for naturalists to range over the whole field of biology. At that time, however, the number of appointments was strictly limited so that few biologists, except those with a medical qualification, could afford to embark on a scientific career without independent means. Heads of biological departments for the most part were men of culture, widely travelled, with an almost encyclopaedic knowledge of their subject, in addition to being experts on some particular branch. Together with the amateurs—who have always played an important role in biological research—the work they accomplished formed the basis for the almost explosive development of the last 50 years and the wonders of modern biology.

Recent British Standards

Laboratory Furniture and Fittings

The publication of B.S.3202: 1960 (price 25s.) marks the culmination of more than seven years of study and drafting by a representative committee under the chairmanship of Mr. W. H. Pritchard of Courtaulds Ltd. These Recommendations represent an immense total of accumulated practical experience on the part of laboratory workers of all kinds and of the designers and manufacturers of laboratory equipment.

The subjects dealt with in detail include the planning and design of laboratories, laboratory benches, fume extraction and piped services, but there is scarcely any aspect of laboratory life and work which is not mentioned in one form or another. A five-page contents list and a comprehensive index have been included for ease of reference.

The committee decided at an early stage in its work that the dimensional standardization which characterizes many British Standards would be generally inappropriate in this field. It was also decided, in view of the speed of development in laboratory construction and furnishing and of the wide variety of purposes for which laboratories are required, that the preparation of a fully comprehensive and authoritative Code of Practice could not at present be undertaken. The Recommendations are accordingly published as a guide only, although they are claimed to represent the best modern practice. They refer primarily to laboratories of a fairly advanced type, such as are required, for example, in Universities, Technical Colleges, research institutions and industrial organizations; in particular they are not, in general appropriate for school laboratories.

It is the committee's intention to keep the Recommendations under constant review. Comments or suggestions for improvement should be addressed to the B.S.I.

Analysis and Testing of Coal and Coke

The British Standards Institution has issued two further revised Parts of B.S. 1016, 'Methods for the analysis and testing of coal and coke' (B.S. 1016, 1960, price 4s. 6d.). Brief synopses of their contents are as follows:

Part 9, '*Phosphorus in coal and coke*' deals with the determination of this element in the fuel ash. A volumetric method, similar to that in B.S. 1016:1942, is specified and details of a colorimetric method have been added. The latter is based on the formation of molybdenum blue by reduction of a phosphomolybdate with either hydrazine sulphate or stannous chloride, followed by measurement of the resulting coloration.

Part 15, '*Fusibility of coal ash and coke ash*'. The procedure for the test is more closely defined than in Part 3A of the standard (which dealt with the assessment of the behaviour of the ash on heating and required the determination of two temperatures: those of initial deformation and fusion).

Three characteristic temperatures are now specified: deformation, hemisphere and flow. More precisely, the temperatures are those recorded (*a*) when the first sign of fusion is visible, (*b*) when the test piece takes the form of a hemisphere, (*c*) when the hemisphere has melted down to one-third of its height. The determination is carried out in either an oxidizing (carbon dioxide or air) or a reducing (equal volumes of carbon dioxide and hydrogen) atmosphere and any departure from the characteristic deformation pattern is noted. Some similarity between the behaviour of ash in this laboratory test and in industrial conditions may be expected.

The German standard method, using a Leitz heating microscope, is briefly described in an Appendix.

Part 14. '*The analysis of coal ash and coke ash*' will not be available for some time, as the subject is at present undergoing investigation. In the meantime, the B.S.I. has issued a preliminary statement with reference to a number of methods of analysis in current use which will in all probability form the basis of the new British Standard and will eventually replace the existing methods of B.S. 1016. This statement (PD. 3714) is being inserted in all copies of Part 15 and can also be obtained free on application.

Bomb Calorimeter Thermometers

In this revised publication (B.S. 791: 1959, price 4s.) requirements for the 12° C. range thermometers specified in the 1954 edition have been excluded and only the more accurate 6° C. range thermometers for use with bomb calorimeters have been retained.

Two grades of accuracy are specified, for seven thermometers for use between 9° C. and 33° C. at either partial or total immersion. The foreword to the 11-page specification states that discussions on calorimeter thermometers in the International Organization for Standardization have been taken into account.

Among the requirements specified are those for material, dimensions, construction, graduation and figuring.

One of the markings to appear permanently and legibly on each thermometer is the number of this British Standard, i.e. 'B.S. 791'. A note explains the purpose of B.S.I's. 'Kitemark' and the conditions under which the well-known monogram may be applied to products.

Among the three appendices to the standard is one listing the manufacturers and identification marks of glasses approved by the National Physical Laboratory.

Copies of these Standards may be obtained from The British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

Association of Consulting Scientists

Following the Annual General Meeting of the Association of Consulting Scientists held in London recently, the following Officers and Members of the Council were elected for 1960-61:

Dr. J. G. Davis (Chairman)
Dr. G. W. Ferguson (Hon. Treasurer)
Mr. W. H. Stevens (Hon. Secretary)
Dr. M. Barent
Dr. H. H. Chambers
Dr. Julius Grant
Dr. J. H. Oliver
Mr. O. W. Roskill
Mr. F. G. Sarel Whitfield.

MEDICINE

by Prof. Sir Charles Dodds, M.V.O., D.Sc., M.D., F.R.C.P., F.R.S.

A STUDY of the earliest records of the Royal Society show that a number of medical men were founding Fellows. Practically all of these were Fellows of the Royal College of Physicians and in order to understand the position at the time it is necessary to describe in some detail the structure and functions of the Royal College of Physicians as it is only by doing that that we shall be able to understand its attitude towards the newly formed Society in Gresham College.

The Royal College of Physicians was founded by Thomas Linacre under Charter of Henry VIII in the year 1518, so it had already been in existence some 140 years before the foundation of the Royal Society. We have a very clear picture of Linacre's reason for founding the College. This was to regulate the practice of medicine in the City of London which, prior to this date, had no overseeing authority whatsoever. In fact, there was no place in Great Britain where it was possible to obtain a formal medical education. Degrees were granted at Oxford and Cambridge without examination and without courses of study, and for those who were not graduates licences to practice were awarded by the Archbishop of Canterbury in London and the Bishops or their Vicars general in the Provinces. The doctors so appointed obtained any medical knowledge they had from the reading of the works of Galen. The majority of successful physicians, however, had travelled abroad and had visited places where formal medical education was in practice. Linacre himself studied in Padua where many of the early physicians went. Leydon was another continental university at which regular lectures in medicine, anatomy and similar subjects were held. Linacre's object in founding the Royal College of Physicians was to ensure that those practising medicine in the City of London conformed to a standard set by the College. The applicants for licence were interviewed by the College officers and were granted licences or not according to the way they fared. The College structure was rather complicated consisting of Fellows, four Censors, a Treasurer, a President and a Council out of which were elected three elders known as Elects from which the President was chosen.

From its foundation in 1518, the College exercised an autocratic authority on the practice of medicine in London and some years later this was extended to the whole of England. The College possesses in its annals a complete record of the proceedings of the Comitia Fellows from its foundation to the present day. The early volumes were fortunately saved from the Fire of London by Dr. Merrett, a founding Fellow of the Royal Society about whom we shall hear more later. The candidates for licence were examined entirely on the basis of their knowledge of the works of Galen and it must be remembered that the Galenical system had persisted from Galen's time right through almost to the 19th century. This system which ascribed all ills to an imbalance in the four humours was of course entirely without any experimental background and consisted really of medieval superstition. It must also be remembered that the knowledge of the circulation had still to await unveiling by Harvey in the early part of the 17th century. Moreover, the physicians at the time of the founding of the Royal Society were an extremely influential body. The President had invariably been recognized by the honour of knighthood or the conferment of a baronetcy and also they were usually attached as physicians to the Royal Household.

This then was the position of the Royal College of Physicians in the year 1660 when the Royal Society was founded. What attitude did the College take to the newly formed Royal Society? It is here that we find a very curious state of affairs. A number of Fellows of the Royal College of Physicians were founding members of the Royal Society yet a study of the Annals of the College contain not a single reference to the Royal Society. There can be little doubt that the College certainly did not look with favour on the newly formed experimental Society. The Treasurer of the College at the time was Dr. Baldwin Hamey, a friend of Harvey's and an opponent to the new progress which he felt threatened the whole structure of Galenism and, therefore, of medicine. In his writings he makes it clear that he regarded the Royal Society as a challenge to the quiet law and order over which the College had taken so much trouble during its 140 years of activity.

There have been many medical men who have been prominent Fellows of the Royal Society and one is faced with a certain amount of difficulty in selecting representatives to cover the three hundred years. The following biographies can be taken as representative of medical Fellows of the Royal Society at various periods. Of the founding Fellows, two are of particular interest, namely Dr. Christopher Merrett and Dr. William Croone.

Christopher Merrett was a founding Fellow of the Royal Society and he was also the first Harveian Librarian of the Royal College of Physicians which was then situated at Amen Corner. The library consisted of a very valuable collection of books including those of Linacre, Caius and Harvey. The latter had left in his will specific instructions for the endowment of a Keeper for the library. He was named Harveian Librarian by the President and Fellows and in addition to receiving a stipend he also was provided with lodgings in the College. During the fire of 1666 the library was completely destroyed and Merrett behaved with considerable bravery in rescuing a number of the more priceless volumes which included the Annals of the College, the first volumes of which were written by John

Caius himself. Merrett sacrificed his own personal library to rescue as much as he could of the contents of the College library. The destruction of the building robbed him of a place of residence and he commenced an altercation with the College demanding compensation. This led to an unseemly quarrel with both sides seeking legal enforcement. Things got to such a pitch that in 1681 Dr. Merrett was expelled from his Fellowship. Merrett appealed to the Court of the King's Bench but the judgment was again given in favour of the college. Merrett died in August 1695 and is buried in the Church of St. Andrews in Holborn. We should be eternally grateful to him for the preservation of the Annals.

William Croone was born in the year 1633 and died of fever in October 1684. As already mentioned he was one of the original Fellows of the Royal Society and made a number of interesting contributions to the meetings at Gresham College. He was noted particularly for his contributions to the Philosophical Transactions under the title 'De Ovo'. Many considered that this forestalled Malpighi's book on embryology. Of particular interest to both the Royal Society and the Royal College of Physicians is that Dr. Croone planned two lectureships, one for the Royal College of Physicians and one for the Royal Society. Both still exist today. The lectureships were not, however, instituted until some time after his death as it was found that his will failed to make provision for their endowment. His widow, who married again, completed the endowment and the lectures were given from that time onwards. The first Croonian lecture to the Royal Society was read in 1738 by Dr. Alexander Steward on muscular motion. The lectures at the Royal College of Physicians were delayed another 11 years. In 1749 the first College of Physicians Croonian Lecture was given by Dr. Thomas Lawrence, a friend of Dr. Johnson. Little more is known about him except that he was a very successful physician.

Sir Hans Sloane is equally interesting from the Royal Society and the Royal College of Physicians' point of view as he is the only man who has occupied the Presidency of both bodies. Born in Ireland in April 1660 of Scottish ancestry, he was brought up in Ulster and very quickly showed his inclination towards the study of natural history. In his early teens he was attacked by what was undoubtedly pulmonary tuberculosis but by very careful avoidance of excesses and a regular course of life he was able to overcome the disease and lived to a very old age. He studied and travelled extensively on the Continent and returned to London having obtained a degree of the University of Orange in the year 1684 and he was then admitted a Fellow of the Royal Society. The greatest physician of the age, Sydenham, took an interest in him and under this Master he acquired an extensive practice in London. He was admitted a Fellow of the Royal College of Physicians in 1687. In that same year he was appointed physician to the Duke of Albemarle whom he accompanied to Jamaica. The Duke's Governorship was interrupted by death and Dr. Sloane remained only 15 months in the Carribean area. During this period he made an extensive collection of the flora and fauna of the island and was, as Munk points out, the first person with a scientific education to investigate this fascinating area. He returned with an enormous collection of specimens which formed the basis of the Sloane collection. He returned to London in 1689 and became the most successful physician in the city. His progress in the Royal Society was rapid. In the year 1693 he was elected Secretary and was responsible for the production of the Transactions. In these he published the result of his work in Jamaica. These were immediately recognized as classics and he became internationally famous, being appointed a Foreign Member of the French Academy of Science. In 1712 he was appointed a Vice-President of the Royal Society. He was physician to Queen Anne and George I, and became a Censor of the College of Physicians in 1705 and was elected President in October 1719. So popular was he that he continued to be elected until 1735. Despite the responsibilities of such a position Sloane was elected President of the Royal Society in 1727 in succession to Newton. He remained in the Chair of the Royal Society until 1740 when he retired to an estate in Chelsea where he eventually died in January 1753 at the age of 92. His collection and his library, at his wish, were kept together and purchased for the nation and, as is well known, formed the basis of the British Museum as we know it today. The library is still one of the most authoritative collections of books and manuscripts of the period.

It can truly be said that no man ever occupied simultaneously such a high position in science and in medicine as Sir Hans Sloane.

One of the most remarkable Fellows of both the Royal College of Physicians and the Royal Society of all time was Thomas Young, referred to by his contemporaries as 'the marvel of his age'. Born in Milverton in Somersetshire in June 1773, he was educated privately and spent a considerable time in the house of Mr. David Barclay of Youngsbury, the well known classical scholar of the time. Mr. Barclay was immediately impressed by the astonishing, nay fantastic, ability of his pupil to learn languages. He very quickly became proficient in Latin, Greek and Hebrew and later added French, Italian and Spanish to his repertoire. Not being content with these, he strayed into the Eastern languages and became proficient in Arabic and others. As a young man he was able to compete on equal terms with the most distinguished classical scholars of his time. He apparently had a memory which must have been something like a modern electronic calculating machine as he never appears to have forgotten anything he was told or read and was always able to produce it to bear on arguments that he was engaged in at the time.

In 1792, having been promised an income from his uncle, he decided to study medicine. He attended lectures by John Hunter and other prominent teachers

of the day. In 1793 he communicated a paper to the Royal Society which was published in the Transactions of that year. So great an impression did this make that he was immediately elected a Fellow, but it was discovered that he was not yet 21 and his election was, therefore, delayed until June 19, 1794, when he was just 21 years of age. This surely in itself must be a record. In 1794 he went to Edinburgh to study medicine and then to Göttingen where he graduated in medicine in 1796. He returned to England and became a commoner of Emmanuel College, Cambridge. In 1801 he became a Professor of Natural Philosophy at the Royal Institution where he delivered a series of lectures on natural philosophy and the mechanical arts which are still read today. He was, however, too progressive and restless of mind to be content with popular lectures and after some two years he resigned from the Royal Institution and in 1802 became Foreign Secretary of the Royal Society and in this office he continued until his death. Graduating in medicine in Cambridge in 1803, he was admitted as a candidate to the College of Physicians in 1808 and became a Fellow in 1809. He occupied a number of positions in the College, being a Censor and a Croonian lecturer. In 1811 he became a physician on the staff of St. George's Hospital which he again held until his death. Contemporaries spoke of him as a competent physician but not a popular one. Sir Benjamin Brodie gives a contemporary picture of him in the following words:—

'The truth is that either his mind, from it having been so long trained by the study of the more exact sciences, was not fitted for the profession which he had chosen, or that it was so much engrossed by other and, to him, more interesting pursuits, that he never bestowed on it that constant and patient attention without which no one can be a great physician.'

His scientific contributions cover a very wide range and were communicated to the Royal Society during the early part of the last century. These include very important papers on vision and Young's researches went a long way to establishing the undulatory theory of light. He is also known for his work on elasticity of solids and gave his name to the famous modulus. He also took a great interest in astronomy and was made Secretary to the Board of Longitude of the Admiralty. This body had charge of the nautical almanack published by the Admiralty and was regarded as one of the most important bodies connected with navigation. Young managed this in a competent way but his Chairmanship was marred by bitter controversies.

Here then we have a picture of what one must admit to be a most remarkable man of his age. Physicist, mathematician, and philologist, but we are not finished with him yet for he added still another subject to those of which he was already master—Egyptology. We have already referred to his astonishing knowledge of languages and indicated that he had studied Eastern languages. He wrote a number of articles in the Quarterly Review on classical subjects and wrote an article on languages in the supplement of the Encyclopaedia Britannica of the day. This remarkable man added yet another achievement to his already long list by being the first to solve, translate and transcribe the Egyptian hieroglyphics. He did this by a study of the famous Rosetta stone and his papers on this are regarded as classical. As the result of his laborious investigations a complete clue to the meaning of the Egyptian hieroglyphics was given for the first time. Unfortunately a controversy developed on the question of priority with the French Professor Champollion, but today it is generally acknowledged that he was responsible for the first break through. Surely he was indeed the wonder of the age.

Turning to more modern times as our final subject we will choose Sir William Osler, acknowledged by all as the greatest living medical personality of his time. Osler was born in Ontario in 1849, his father, a clergyman, having emigrated from Falmouth. He was educated at a school near Toronto where the Anglican warden, Father Joseph, inspired him with a love of books. At a very early age he became familiar with Browne's 'Religio Medici', and Epictetus and Marcus Aurelius, and there can be little doubt that these works had a profound influence which remained for the rest of his life. He studied in Toronto and McGill, graduating in 1872.

Leaving Canada he toured the Continent extensively, finishing up as a research worker for a short time in the Physiological Laboratory of Sir John Burdon Sanderson at University College. Returning to Montreal he was made a Professor of the Institutes of Medicine at the early age of 25 and in 1878 was elected physician to the Montreal General Hospital. He threw himself into pathological research and his lectures in physiology and pathology became the most noted on the continent of North America. In 1884 he became Professor of Medicine in the University of Pennsylvania. His great appointment, however, came some five years later when he became the first Professor of Medicine at Johns Hopkins Hospital at Baltimore and physician to the hospital. This appointment was perhaps one of the most important historically in medicine, as the famous school in medicine at the Johns Hopkins was founded with Osler as Professor of Medicine and so one of its leaders. His colleagues were the famous Welch, Professor of Pathology, and Halstead, Professor of Surgery. These three men built up the School which has been acknowledged as one of the finest in the world. During this period Osler wrote his famous book 'The Principles and Practice of Medicine' which was published in 1892. This immediately became a classic and is still regarded as one of the most valuable works in medicine. There followed a series of classical researches which put Osler right at the top of the clinical tree. In 1904 he was elected to the Regius Chair of Medicine at Oxford and this he accepted gladly. He became physician to the Radcliffe Infirmary and was acknowledged one of the greatest medical consultants of his age. He was deeply interested in books and for a time was curator of the

Bodleian Library and a delegate to the Clarendon Press. In the Royal College of Physicians he held many high honours including being a Harveian Orator and Lumeliam Lecturer in 1910. He was elected a Fellow of the Royal Society in 1898.

Osler inspired affection and devotion to all who came in contact with him. This was of a particularly wide spectrum from the most junior of his students to the most senior of his colleagues. Perhaps the most famous of his philosophical writings is his 'Way of Life', published in 1913.

Space does not permit us to deal with the many other fascinating medical Royal Fellows. Medicine has been continuously represented by distinguished figures in the Royal Society and we must just take those quoted as typical of the long line of distinguished men who were interested in both the Royal College of Physicians and the Royal Society.

BOOK REVIEWS

Cosmetic Science, edited by A. W. Middleton, Ph.D., F.R.I.C. London: Butterworths Scientific Publications. 1959. 60s. pp. 327 + xv.

The title of this book is scarcely justified by its contents, but how, indeed, could one expect it to be, having regard to the limited scope of its component parts (a collection of papers individually contributed) and its brevity (320 pages). It is, in fact, a carefully edited version of the Proceedings of the First British Congress on Cosmetic Science, held in London in 1959 under the aegis of the Society of Cosmetic Chemists of Great Britain. The papers, some of which are of considerable interest, have been neatly arranged—as they were during the congress itself—under the general headings:

Analysis of Raw Materials.
Assessment of Finished Products.
Manufacturing or Processing.
Biological Assessment.

This is not, of course, a book for those who wish to gain information about the constitution or formulation of modern cosmetics and allied preparations. In any case, the practical making and marketing of cosmetics still owes far more to advertising, the influence of fashion, art and empiricism than it does to science.

But perhaps enough, or more than enough, has been said about what this book is not. Perhaps the easiest way to describe what it is consists in detailing the contents. Allowing for the 'discussion' that comes after each paper, these contents are:

Analytical methods in assessing the value of perfumery raw materials (H. van den Dool).
Ultra-violet spectrophotometric procedures in essential oil examination (J. B. Stenlake and W. D. Williams.)
Specifications for raw materials and finished products (N. J. Van Abbé).
Trends in mechanization in laboratories (R. Barrington Brock).
The function of consumer testing in product development and marketing (L. H. Ovens).
Laboratory tests as a basis for accurate product market testing (D. H. Powers).
Product evaluation from the rheological aspect (L. S. Adler).
The patch test in the diagnosis and prevention of cosmetic dermatitis (E. J. Moynahan).
Effect of rheological properties on mixing and heat-transfer operations (E. S. Sellers and W. L. Wilkinson).
Heat transfer in cosmetic manufacturing processes (V. O. E. Bryant).
Corrosion of iron and aluminium (K. F. Lorking and J. E. O. Mayne).
Fundamentals of filtration (D. M. Wyllie).
The present state of the cosmetic industry (W. S. Bullough).
Recent advances in the biology of the skin (F. J. Ebling).
Cosmetics, allergy and skin (J. G. Feinberg).
Cosmetics as a factor in civilization (R. H. Marriott).
Postscript.
Index of Contributors to Discussions.
Subject Index.

Some of the contributions to the discussion periods appear to have been cut down by the editor; and certainly the tone of the more lively exchanges has been modified. This may be all to the good.

The reviewer's own view is that 60s. is a rather high price to pay for a volume of this kind, interesting and instructive as it undoubtedly is. Perhaps it would prove advisable to issue the proceedings of future congresses in a less ambitious and correspondingly cheaper format. As an example may be quoted the Proceedings of the Scientific Section of the Toilet Goods Association, U.S.A.—F.V.W.

Meldola Medals for 1959

Two awards of the Meldola Medal are to be made for 1959. The recipients will be:

John Ivan George Cadogan, for his work in the field of organic chemistry, with special reference to reactions of free radicals in solution and to reactions of organophosphorus compounds.

Thomas Cudworth Waddington, for his work in the fields of physical and inorganic chemistry, with special reference to thermochemistry and reactivity of azides; photoconductivity of anthracene; lattice energies and infra-red spectra of inorganic salts; and liquid hydrogen chloride as an ionizing solvent.

MICROBIOLOGY

by

Lt. Col. H. J. Bensted,

O.B.E., M.C., M.R.C.P.

Lt. Col. H. J. Bensted, O.B.E., M.C., M.R.C.P.

Introduction

Three-hundred years ago microscopy was a very ill-equipped science and microbiology did not exist. It is true that naturalists were beginning to look at small living creatures through magnifying glasses, but these imperfect instruments could only provide enlarged pictures of objects already visible to the naked eye. In 1665 Robert Hooke (1635—1703; FRS 1663) published his famous *Micrographia*, but this book did little more than display large pictures of small objects. Hooke may have been a mechanical genius but neither his microscopes nor any others then known could give any appreciation of true microscopic life as we understand the term today. Apparently, however, such instruments did exist for in 1673 Oldenburg, the Secretary of the Royal Society, received a remarkable letter in Dutch in which the writer described with great clarity and, as later was proved, equally great accuracy minute living creatures quite invisible to the naked eye which he had seen through a microscope of his own construction. The writer of the letter was Antonius van Leeuwenhoek* from Delft in Holland and he continued to write similar letters to the Royal Society for the next 50 years all of which contained some exciting, almost unbelievable, information about microscopic life, including descriptions of the three morphological forms of bacteria as we know them today—micrococci, bacilli and spiral organisms. Leeuwenhoek may be justly regarded as the father of microbiology, and although he was a foreigner and never attended a single meeting of the Fellows was unanimously elected FRS in 1680.

After Leeuwenhoek's death some of the microscopes he bequeathed to the Royal Society were examined by the naturalist Henry Baker (1698—1774; FRS 1740). They were unorthodox in form but were in fact simple magnifying glasses with a single biconvex lens, not compound microscopes. How Leeuwenhoek made his lenses was never disclosed, but it was clear that they were ground surfaces and not melted glass globules as some believed. The greatest magnifier examined had its focus at 1/20 in. and, according to present day reckoning, magnified 200 diameters. Even so it is not understood how he could, with this magnification, see so clearly (which he undoubtedly did, for he was a very truthful man) some of the objects he described and it has been suggested, by later writers, that he may have employed some form of dark field illumination.

Doctrine of Abiogenesis

During the years that followed there was much controversy about the origin of the microscopic forms of life described by Leeuwenhoek as existing in what appeared to be pure water. They were thought to have arisen spontaneously and many arguments were put forward and experiments devised, to support this theory of spontaneous generation or abiogenesis. The long controversy between Father Needham (J. T. Needham 1713—1781; FRS 1746) and Spallanzani, the famous Italian experimental scientist, was a classical example. Spallanzani's conclusive experiments should have finally disposed of spontaneous generation as a doctrine. It did not suffer extinction, however, until the carefully devised experiments of Pasteur and his assistants had clearly shown that the doctrine was false. Nevertheless H. C. Bastian (1837—1915; FRS 1868) a great champion of abiogenesis was extremely critical of some of Pasteur's experiments and was constantly in conflict with him. Indeed there is little doubt that some of these criticisms were valid and appreciated by Pasteur and his colleagues, who then devised more convincing experiments to prove the unsoundness of the theory of abiogenesis.

*It is appreciated that Leeuwenhoek, as a foreigner, does not qualify for full consideration in this article but because of the importance of his contributions and because his scientific life virtually belonged to the Royal Society it is felt that this brief reference to him and his work is not out of place.

The Influence of Pasteur

The epoch-making discoveries of Pasteur were followed with great interest by many British scientists who were themselves stimulated to make experiments in the same field. The introduction in 1877 of fractional sterilization by J. Tyndall (1820—1895; FRS 1852) was an outstanding example and 'Tyndallization', as it was called, proved to be a most valuable contribution in the fight against the doctrine of spontaneous generation and remains today, in principle, as one of the most important procedures in bacteriological sterilization.

The Germ Theory and Antiseptics

The doctrine of spontaneous generation was gradually replaced by the 'Germ theory' of disease. At that time hospitalization was generally dreaded by both patients and their relatives alike, especially with regard to admissions for surgical operations, because post-operative sepsis, hospital gangrene and cross-infection were together responsible for a very high mortality rate. Lister (1827—1912; FRS 1860; PRS 1895—1900), then Professor of Surgery in Glasgow, fully appreciated that sepsis was retarding any real surgical progress. He was much impressed by Pasteur's discoveries and decided to approach the problem as a scientist and he became an earnest student of bacteriology. He made many valuable observations with regard to bacterial contamination and incidentally was the first person to obtain, by dilution technique, a pure culture of a bacterium. He finally devised the operating technique which revolutionized surgery. Using sterilized instruments, ligatures and dressings and operating in what was virtually a phenolic cloud he almost completely overcame the hazard of sepsis. As a result, there was a spectacular reduction in the death rate from sepsis and a great lessening of hospital cross-infection for his antiseptic methods were employed in the wards as well as in the operating theatre. Lister's work, more than that of any other medical scientist at that time, had the most important influence on the medical profession in general.

The Establishment of Bacteriology as a Science

A new era was beginning. Bacteriology was emerging as an organized science and its intense study in France and Germany yielded results which completely overshadowed the work of the comparatively small band of workers in Britain interested in the subject. So great was the continental influence that few reports of progress in bacteriology that were published appeared in any language other than French or German. At the beginning, the German school tended to concentrate on the study of individual bacteria, parasitic and saprophytic, for as a result of Koch's solution of the problem of pure bacterial cultures, new ones were constantly being identified.

Immunology

The French school took another direction and concentrated more on the study of the prevention of infectious disease than pure academic bacteriology. Thus a new branch of microbiology came into being—immunology—the study of resistance to infectio whether natural or acquired. Pasteur's experiments o rabies and anthrax formed the basis of this new study.

Long before the nature of infection, the spread of epidemic diseases and the principles of immunity were understood, Edward Jenner (1749—1823; FRS 1798) observed that naturally acquired cowpox protected against infection by smallpox. His classical experiment, whereby he inoculated a boy with cowpox and later submitted him to challenge with infective material from a small-pox patient without ill effect, was an immunological experiment of the highest importance. It formed the basis from which all our knowledge of immunology developed, but it was many years before the full implications of the successful experiment could be properly appreciated.

With increasing interest in bacterial infection numerous examples of the apparent inhibition of bacterial growth in the presence of body fluids, particularly the blood, were recorded and in 1872 David Cunningham (1843—1914; FRS 1889), produced experimental evidence to show that normal blood had some power of inhibiting the growth of certain organisms and retarding putrefaction. Watson Cheyne (1852—1923; FRS 1894), the famous surgeon who was closely associated with Lister in later years had previously been an eminent bacteriologist. He made a number of valuable observations relating to natural immunity. The elegant experiments of G. H. F. Nuttall (1862—1937; FRS 1904) showed that this inhibition of bacterial growth depended on a thermo-labile bactericidal substance present in blood which could be studied and its potency measured with some degree of accuracy. Within the terms of Nuttall's experiments his results were fully confirmed by other workers.

Phagocytosis and the Opsonic Theory

Another immunity system which involved the phagocytosis of bacteria by the polymorphonuclear leucocytes was studied by W. B. Leishman (1865—1926; FRS 1910), A. E. Wright (1861—1947; FRS 1891) and S. R. Douglas (1871—1936; FRS 1922). In 1903 Wright and Douglas propounded their Opsonic theory to explain the effect of a substance in the blood serum—opsonin, they called it—on phagocytosis of infecting bacteria. Opsonins, they said, acted on bacteria in such a way as to render them an easy prey to the leucocytes. A method was devised for estimating the opsonic power of the serum and the opsonic index expressed the comparative immune state of a person against a particular infecting bacterium. The method was much in vogue for the control of vaccine therapy in the years preceding the first world war. The accuracy of the test and the significance given to the findings were doubted and criticized by many other workers and at the present time little interest is expressed in the opsonic theory.

Antibacterial Substances

In 1922 Alexander Fleming (1881—1955; FRS 1943) found a bacteriolytic substance in tears, nasal mucus and other secretions which was called lysozyme. This interesting substance, an enzyme, appears to initiate lysis by splitting certain polysaccharide fractions of susceptible bacteria. It is relatively thermolabile and only certain bacteria are sensitive to its action. In spite of its interest the significance of lysozyme remains uncertain. Fleming's major discovery in 1929 of the antibacterial substance, penicillin, in a culture of *Penicillium notatum* created only mild interest at the time. The story of the development of this amazingly valuable substance has been so much publicized that further comment here is unnecessary.

Prophylactic Vaccines

In the field of preventive medicine by artificially induced immunity, the initiation of anti-typhoid inoculation in 1897 by A. E. Wright stands out as a very early example, and of all bacterial prophylactic vaccines the anti-typhoid are more widely used throughout the world than any other. Wright's original experiments in India were spectacular and in spite of the very unpleasant reactions that followed the injections of the early preparations of the vaccine, anti-typhoid inoculation came to be regarded as the most potent weapon against infectious of the enteric group of fevers. W. B. Leishman, assisted by other RAMC officers, was responsible for most of the later investigations of the vaccine and its eventual modifications. Although the methods for maintenance of the cultures of the strains of organisms used for the TAB (typhoid and paratyphoid A and B) vaccine were changed, the method of preparation remained essentially the same until 1941 when Arthur Felix (1887—1956; FRS 1943) introduced the alcohol treatment for killing the organisms and preserving the vaccine. A year or two later Felix's method was introduced into the Army preparation, but in spite of the high hopes for the new vaccine, experience has so far failed to produce evidence of its superiority in the field, over the heat-killed phenol-preserved vaccine as a protection against infection.

Bacteria and Specific Infections

In the realm of pure bacteriology the German school, with Koch as its master, was supreme in the 1880's and the identification of the agents responsible for most of the bacterial infectious diseases was largely accomplished by its members. The identification of the cause of undulant or Mediterranean fever was however an exception. In 1887 David Bruce (1855—1931; FRS 1899), an Army medical officer stationed in Malta, isolated from the spleen of a patient dying of undulant fever a small gram-negative organism which he named *Micrococcus melitensis*. Bruce spent several years in the island, further studying the disease. His original observations were fully confirmed and in 1920, in recognition of his work, the generic name of the organism was changed to *Brucella*. Bruce was an outstanding personality, a true scientist and at the same time a leader of others who achieved distinction in the field of microbiology.

In 1892, Nuttall who was already recognized as a serious research worker in the field of immunology, collaborating with the American bacteriologist, William Welch, identified the gas-gangrene organism now known as *Clostridium welchii*. Charles Martin (1866—1955; FRS 1901), who made many contributions of value over a wide field in biological science must here be mentioned for his classical observations on the mechanism of the transmission of *Pasteurella pestis* by fleas in outbreaks of plague. Another eminent microbiologist, Charles Todd (1869—1957; FRS 1930), was one of the first to study the toxin of Shiga's dysentry bacillus (1904).

Antigenic Constitution and Bacterial Variation

The demonstration in 1896 of the agglutination of typhoid bacilli by the blood serum of a patient with enteric fever was the beginning of a long series of investigations in which immune reactions between various bacteria and their artificially prepared homologous antisera were used to study antigenic constitution. These antisera were also used for the identification of pathogenic bacteria on the assumption that the simple agglutination reaction indicated specificity. When it was later found that this specificity was not always complete, it was concluded that where such cross-reactions occurred the organisms must contain some common antigen component. Although it had been found possible in 1908 to separate the organism of paratyphoid B fever from that of mouse typhoid by the absorption of agglutinins procedure, there was no proper understanding of the complex antigenic structure of many organisms, among which those motile forms belonging to the *Salmonella* or food poisoning group may be taken as an example. In 1922 F. W. Andrews (1859—1932; FRS 1915), who had already done notable work in his study of the dysentery bacilli, discovered phase-variation and showed that some of these *Salmonella* organisms, possessed a double H-antigen-complex, one part of which was specific and the other part non-specific and present in many other types. The explanation of phase-variation in diphasic *Salmonella* organisms by Andrewes proved to be of the greatest importance and opened the door to Bruce White (1891—1949; FRS 1941) who was shortly to embark on his intensive and detailed study of the antigenic structure of the salmonella group and eventually clarify, with others, our understanding of the complicated antigenic complexes involved. The antigenic analyses of *Salmonella* organisms by Bruce White formed the basis for the present Kauffmann-White schema for the identification of more than 500 different members of the group.

As early as 1904 it had been observed that whereas motile gram-negative bacilli agglutinated in large snowy clumps, non-motile forms agglutinated in fine

granular masses. This observation had been largely overlooked and its significance not appreciated. In 1917 Felix and his colleague Weil found that a *Proteus* culture which he had isolated from a patient suffering from typhus could occur in two forms: a motile form which in culture swarmed rapidly over the surface of the medium and agglutinated as large snowy flakes and another which was non-motile and grew as discrete colonies and agglutinated in fine granules. The swarming motile form was called the *Hauch* (H) form and the non-swarming culture the *Ohne Hauch* (O) form. The O-culture gave a specific agglutination with serum from a typhus patient whereas the reaction with the H-culture was non-specific. These observations led to the development of the Weil-Felix reaction as a diagnostic test for typhus. The demonstration of H-O variation was also a most important step in the appreciation of antigenic constitution of bacteria. Felix's name is also associated with the discovery in 1934 of the Vi-antigen, the third antigenic complex of the typhoid bacillus, which was among the first of the so-called capsular antigens to be identified.

Another type of bacterial variation, S-R variation, was observed by J. Arkwright (1864—1944; FRS 1926). This form of variation involves a loss of the somatic or O antigens, which are believed to be mainly concentrated on the surface of bacterial cells, and leads to important changes in the properties of the organism concerned. It is characterized by a change in the appearance of the normal smooth surface of the bacterial colony to a rough state.

Epidemiology

Previous to the opening of the bacteriological era any advance in our knowledge of infectious diseases or their method of spread depended on the unaided observational powers of physicians. For instance, at a time when typhus and typhoid fevers were not recognized as separate unrelated diseases it is noteworthy that Thomas Willis (1621—1675; FRS 1663) was able to record differences in the epidemiological pattern of the two diseases. Many years later, but still without the advantages of any new investigational tools of value, William Budd (1811—1880; FRS 1871), an early supporter of the germ theory of disease, displayed an even greater knowledge of the exact details of the natural history of typhoid fever.

Experimental epidemiology has become a separate branch of microbiology but this has been possible only in recent years. In 1925—30 W. W. C. Topley (1886—1944; FRS 1930) and Major Greenwood (1880—1949; FRS 1928) conducted their classical experiments in the study of the epidemiological pattern of *Salmonella typhimurium* outbreaks of infection in mice induced under controlled conditions. These remain as models of experimentally induced infections in colonies of laboratory animals.

Non-bacterial Diseases

Towards the end of the 19th century, when so many of the causative agents of the infectious diseases were being identified, evidence was accumulating to show, or to suggest, that all such diseases were not caused by bacteria. Indeed there was good reason to believe that certain diseases that seemed to be insect-borne were caused by protozoan parasites which could be demonstrated in the patient at some stage of the illness. There were other insect-borne diseases in which no parasite could be demonstrated at any stage.

Protozoan Parasites

The malarial parasite was discovered in 1880 but it took Ronald Ross (1857—1932; FRS 1901) with Patrick Manson (1844—1922; FRS 1900) almost 20 years to work out the complete life cycle of the parasite. David Bruce (1895) was able to show that nagana, a fatal disease in Africa of horses and cattle, was caused by a trypanosome which was carried by the tsetse fly *Glossina morsitans*, and in 1903 he also showed that *Trypanosoma gambiense*, which had been identified a few years previously as the cause of human sleeping sickness, was transmitted by the bite of another tsetse fly *G.palpalis*.

W. B. Leishman, although primarily a bacteriologist, discovered the Kala-azar parasite in 1903. He found the parasites in spleen smears, made *post mortem* from a soldier who died of dumdum fever in Netley Hospital two and a half years previously, but at the time of the original examination he had been unable to appreciate their significance. He eventually came to the mistaken conclusion that the curious rounded bodies he saw in the spleen were degenerated forms of trypanosomes. Later, when it became possible to cultivate the parasite in the laboratory, it was seen to be a flagellated protozoan blood-parasite different from the trypanosomes. Leishman's discovery was recognized by giving the parasite the generic name *Leishmania*. The diseases of which *Leishmania* organisms are the cause are called the LEISHMANIASES.

C. M. Wenyon (1878—1948; FRS 1927) was an eminent protozoologist, and is probably best known for his work on the intestinal protozoa. Clifford Dobell (1886—1949; FRS 1918) was a great authority on the *Entamoebae*, but he had many other interests in the microbiological field.

Animal Viruses

Some of the diseases, accepted as being caused by ultramicroscopic viruses, were characterized by an intra-cellular reaction and the development, visible by the ordinary light microscope, of inclusion bodies in the cells. John Ledingham (1875—1944; FRS 1921) investigated the inclusion bodies found in smallpox or variola and in 1924 showed, with others, that these granules were infective. His observations left little doubt that they were in fact intracellular colonies of the virus of variola.

The great pandemic of influenza of 1918—19 was clearly not a simple bacterial disease and many bacteriologists considered that the outbreak was probably

a manifestation of a virus infection complicated by superimposed bacterial infection, of which the most important species appeared to be the influenza bacillus (*Haemophilus influenzae*). Little progress was made towards the solution of the problem, largely owing to the fact that a suitable susceptible laboratory animal had not been found for the experimental transmission of the infection, until the brilliant experiments of P. P. Laidlaw (1882—1940; FRS 1927) and his colleagues in 1933 demonstrated the truth of what was previously only conjecture. Laidlaw had just completed his studies on the cause of dog distemper which he had been able to show was due to a specific virus. The success of this investigation had been largely due to the fact that he had found that the ferret was very susceptible to the virus of dog-distemper and when he decided to start his influenza investigations he had, among other laboratory animals, a stock of clean laboratory-bred ferrets.

Laidlaw found that the ferret was highly susceptible also to the infective agent of influenza and when he instilled the filtered nasal washings from a patient suffering from epidemic influenza intranasally into a clean ferret he was able to induce an influenza-like infection which eventually led to the production of protective antibodies in that animal. Normal ferrets were so susceptible that the infection was readily transmitted to the animals from the sneeze of persons incubating the disease. Elford (1900—1952; FRS 1950) had prepared a series of filter membranes of known porosity-size and he demonstrated that the particulate size of Laidlaw's human influenza virus was of the same order as the swine influenza virus. These studies of Laidlaw and his colleagues are considered to be among the most important of the early investigations in the nature of virus diseases.

Bacterial Viruses or Bacteriophages

In 1915 F. W. Twort (1877—1950; FRS 1929) described the curious punched-out appearance of some colonies of staphylococci which he had cultured from samples of calf-lymph and showed that the phenomenon was due to a lytic substance present in bacteria-free filtrates of such cultures. The lytic effect could be transmitted in high dilutions of these filtrates from culture to culture of the susceptible bacterium. The phenomenon was subsequently shown to be related to the presence of a living filterable agent, infective for the particular bacterium concerned in which it was able to multiply, which was called bacteriophage or phage. Twort himself was little concerned with later developments of bacteriophages, but he gave a very complete description of the original phenomenon and there can be little doubt, in spite of the claims of d'Herelle, that Twort was first in the field and its designation, 'Twort-d'Herelle phenomenon', seems just. One important development of bacteriophage investigations was the demonstration of the specificity of the sensitivity of certain bacterial cultures to the action of particular phage preparations. By this means it was found possible to divide a bacterial antigenic species into a number of sub-types by phage typing schemes that have become valuable precision tools for the epidemiological investigation of outbreaks of certain infectious diseases. One of the most valuable of such schemes owes its development to Felix and concerns the typhoid and paratyphoid schemes of phage typing, but the more important development from an academic point of view, relating to the study of bacterial genetics is outside the scope of this article.

Our terms of reference do not permit us to discuss or consider any of the more recent developments of microbiology, but it seems fitting in this concluding paragraph on the achievements in this field of past Fellows of the Royal Society to point out that although the birth of microbiology and its early development owes so much to non-medical scientists, it was the application of microbiology to the problems in human medicine by medical scientists that led to its spectacular progress in the later part of the 19th century. Indeed the field was almost closed to those trained in other disciplines. In recent years, however, microbiology has attracted the biochemist, the general biologist and the physicist together with others. The strict barriers no longer exist between the biological and non-biological sciences as judged by standards of other days and it would seem that we can look forward to much more integration than was previously thought desirable or even feasible.

SCIENCE FOOD

A special issue of *Laboratory Practice* will be published in September celebrating the Adulteration of Food Act, 1860. Among the articles appearing in this issue will be the following:

1. History of Food Laws by J. A. O'Keefe, O.B.E.

2. Function of Government Departments by Dr. H. R. Barnell.

3. Research in the Food Industry by Dr. F. H. Banfield.

4. Contribution of the Public Analyst by T. McLachlan, F.R.I.C.

5. Food Additives by Prof. A. C. Frazer.

6. Fungicidal and Insecticidal Residues by Dr. J. M. Barnes.

7. Antibiotics in Foods by H. B. Hawley, B.Sc.

AGRICULTURE

by

Prof. H. D. Kay, C.B.E., D.Sc., Ph.D., F.R.S.

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AGRICULTURE is no exception to the general rule, that, in the three hundred years since the foundation of the Royal Society, the activities of a long succession of Fellows have stimulated the development of every industry or profession to which science or scientific method can be applied.

At one time agriculture was considered rather as a traditional art than as having much connection with science. This may well have been true of ancient, or even of pre-Caroline farming in Britain, as it is undoubtedly true of what passes for farming in some primitive countries today, but it is certain that, in the more technically advanced countries, successful modern agriculture is as dependent as any other industry on applied science. The farming 'art' nowadays consists, for the most part, in knowing how to use existing scientific knowledge and technical machinery to the best advantage in circumstances which are changing with every alteration in the meteorological or the economic climate.

Many of the Fellows of the Society, in its early days, were landowners who had good reason to take a direct interest in the use of new knowledge and the scientific method for the improvement of the productivity of their estates. It is hardly surprising that only a short time after the foundation of the Society an agricultural Committee was formed. This, by an obvious derivation, was named the Georgical Committee. It was appointed in March, 1664, with Mr. C. Howard as Chairman, and consisted of as many as 32 Fellows.

Its first action was to endeavour to collate, by careful enquiry from various parts of the British Isles, existing knowledge of good husbandry practice. A formidable questionnaire was prepared, under two main headings 'for Arable' and 'for Meadows', and with no less than 25 sub-headings. Individual members of the Committee were assigned to investigate, on the basis of the questionnaire, different districts; e.g. John Evelyn (of the 'Diary') and Mr. Hill took on Kent, C. Howard Surrey and Berkshire. Three typical examples of the sub-headings may be given:—1. 'What peculiar preparations are made use of to these Soyles for each kind of Grain; with what kind of manure are they prepared; when, how, and in what quantity, the manure is laid on' (incidentally these are questions which Lawes and Gilbert attacked experimentally at Rothamsted two hundred years later); 2. 'What are the Waies of preserving any store of separated Grain from the Annoyances they are obnoxious to'; 3. (from the 'for Meadows' sub-headings) 'What kind of Grass is fitted to be preserved for Winter-feeding and what Grass is best for Sheep, for Cows, Oxen, Horses, Goats'.

The Georgical Committee, meeting as it did twice per month, was evidently not lacking in enthusiasm, but, as may happen with elaborate questionnaires, the results were disappointing. It is likely that the Great Plague of 1665 followed by the Great Fire of London in 1666, seriously interfered with what had been hoped to be a complete coverage. Nevertheless, reports from Devon and Cornwall, Gloucester, Kent and Yorkshire, prepared by various Fellows, are to be found in the Society's archives, and a study of these reports gives valuable information on what methods the better farmers were using at that time. It is evident that tradition, and rule of thumb, prevailed almost everywhere. The Georgical Committee realized that any substantial improvement in practical husbandry, and in the quality of the products from the land, would require new scientific knowledge of many different soils, and of what the real factors were that determined soil fertility. In this connection, knowledge of plant and animal chemistry and physiology would also have to be sought.

The early transactions contained a sprinkling of papers in these fields by members of the Georgical Committee and other Fellows. Contributions came from John Evelyn (mentioned above, and one of the founder

Fellows of the Society) on fruit trees, two by J. Winthrop on the cultivation of maize (1662 and 1678), one by Francis Willughby and John Ray on the motion of sap in trees (1669), by John Ray and Samuel Dale on seeds (1674), by Martin Lister on Juices of Vegetables (1696), by Patrick Blair on 'Finding the vertue of Plants by their Structure'. Manuring, natural and artificial, was one of the earlier subjects studied; the use of quicklime, of triturated sea shells, of sand, of seaweed, received attention in papers by Sir George Mackenzie (1675), by William King, Archbishop of Dublin and other Fellows. Even trace elements in plants were mentioned; J. Eames in 1711 stated 'that plants do really contain Iron and that this metal does necessarily enter into their Natural Composition'. Stephen Hales, perhaps best known for his demonstration in 1733 that mammals have a high arterial blood pressure, also worked on the circulation of sap in the plant. Sap, he found, ascends with a force 'capable of balancing a column of mercury 38 inches high' and he wished to know how this pressure was attained—a question to which, even in 1960, a complete answer cannot be given. Hales studied also transpiration in plants, and their water requirements.

Early in the Society's history an endeavour was made to answer farming enquiries received from practitioners in different parts of the country. One of the early Fellows, John Houghton, published, between 1681—1683 and again between 1692—1703, a series of weekly 'Letters for the Improvement of Husbandry and Trade'. The Society at this stage was feeling its way, but the view that it should engage in running a kind of agricultural information bureau for the practical farmer seems to have lapsed. I have not been able to ascertain when the Georgical Committee was officially wound up, but, as regards agriculture, the trend of the Society's activities during the 1700's was away from the immediate survey and the *ad hoc* problems that had interested the early Committee and towards the underlying botanical and zoological studies in taxonomy, anatomy and physiology. An occasional investigation in soil chemistry was published, e.g. one by S. Tennant on the effect of burnt magnesian, as compared with burnt calcareous, limestone on the growth of plants.

It is apparent that in relation to farming the function for which the Society was better fitted, that of stimulating, and, through its Fellows, taking part in an *experimental* attack on problems in the basic sciences relevant to agriculture on the one hand, and encouraging the same type of approach, armed with the basic knowledge, to field problems on the other, was coming more and more to the fore during the eighteenth century. Unfortunately, during that century, though scientific methods and thinking were being adopted by a few outstanding agriculturists, their further spread was slowed by the archaic conditions of land tenure, and by the accompanying poverty, ignorance and intense conservation of all but a very few peasants and cultivators. These are hindrances from which English agriculture, during the last two hundred years, has been increasingly relieved, but which still very seriously limit food production in so many underdeveloped countries in the world today.

The work of Fellows that I have mentioned above was mainly on plants. Fellows in the early days of the Society also made contributions on zoological or animal husbandry topics of farming significance. Robert Boyle, for example, worked on 'The prevention of Rott in Sheep'. The ichneumon fly, the locust, aphides and termites were studied. That the tissues and even the bones are subject to continuous and fairly rapid chemical changes in the living animal was shown in the 1730's by Belchier and others. Fellows' experiments in the middle of that century led to an appreciation of the part played by 'ferments' in digestion. Scientific aspects of reproduction in farm stock were studied during these years, by a number of Fellows, but the details of the process of fertilization of the female remained a mystery until well into the 19th century. Sir Hans Sloane, president of the Society from 1727—1741, was active in introducing experimental methods into the study of animal functions with benefit to medicine and to agriculture alike.

The 18th and the early 19th century in agricultural Britain were the times of the great 'improvers' of farming methods farm plants and farm stock—Viscount Townshend—'Turnip Townshend' of Raynham in Norfolk (1674—1738), Jethro Tull of Howberry (1675?-1741) who introduced horse-hoeing and invented the seed-drill; Robert Bakewell (1725—1795) who bred greatly improved sheep and longhorn cattle; The Marquess of Rockingham (1730—1782) who experimented with farm drainage and manuring methods; Charles Collings (1751—1836) and his brother Robert, who developed the shorthorn breed of cattle; Thomas Coke of Holkham (1752—1842) who experimented with crop rotations, manures, improved seeds and new farm plants. Of these, Townshend and Rockingham were Fellows of the Society.

Townshend, the first of those just mentioned, was a far-seeing experimental agriculturist with sufficient capital to carry into practice on his large estates any experimental findings of promise. He brought into successful cultivation much land in Norfolk that was previously entirely unproductive and instituted a system of crop rotation, adjusted to the soil and climate of the district. In his introduction into Norfolk of the turnip, Townshend provided a major contribution to the solution of the problem of providing feed for farm stock during the winter months that had confronted animal husbandmen in Britain for centuries. He first tested, and then made extensive use of, Jethro Tull's methods for seed-drilling and for cultivation.

Further, his landowning neighbours, and others who had had his successful farming methods explained to them, began to follow his lead. An important consequence was that the movement towards 'inclosure' was fostered. The lack of fencing in the earlier centuries had very severely handicapped agricultural production in

Britain as it still does today in large areas in East Africa and elsewhere.

As a consequence of the experiments and the pertinacity of the 'improvers' and their disciples, English farming was able steadily to increase the yield and quality of its products, and so to feed a human population that had doubled between 1700 and 1800. That the mounting population could be fed and that at a much higher standard of nutrition than existed at the beginning of the century was due to three main causes. The first was the spread of the new experimental approach to both basic and *ad hoc* problems which the Royal Society in Britain and analogous bodies in Western Europe were promoting; the second was that landowners and tenants, now that the possibilities of 'improvement' had been demonstrated and there was an increasing market for products of better quality, were putting both new knowledge and new capital into their farms; the third was that Government policy, implemented in Acts of Inclosure which became more numerous as the century advanced, was resulting in the bringing into systematic cultivation of derelict common land and other waste areas. Both output per acre and quality of product steadily improved. Thus while in 1710 the average weight of beeves at Smithfield market was 370 lb. and sheep 28 lb., in 1795 the average figures had risen to 800 lb. for beeves and 80 lb. for sheep. 'Instead of poor salted meat from old animals, peasants began to eat fresh meat, and wheaten bread ceased to be a luxury'. Exactly what proportion of these advances could be ascribed to the work of Fellows would hardly be a profitable subject for a Ph.D. thesis, but undoubtedly a large part was due to Fellows such as Townshend and Rockingham who had been experimenting with and improving methods of plant and animal husbandry, including the breeding of better stock and the provision of more and better winter feed for such stock.

From about 1770, the use of artificial manures, such as crushed bones (of which increasing quantities were imported), wood ashes, and of composts such as those employed by Rockingham, became widespread; nitrate of soda and guano began to come in from abroad at the turn of the century. Sir Humphrey Davy, who became P.R.S. in 1820, had been appointed by the recently founded Board of Agriculture as its Professor of Agricultural Chemistry and began investigations on the relationship between the constituents of the soil and the living plant. He also gave lectures on the applications of chemistry to agriculture which aroused much interest amongst the more intelligent farmers and landowners.

During the latter part of the century, the observant Arthur Young (who later became a Fellow) began writing on methods of agricultural improvement, and particularly on crop rotations and on drainage and cultivation, publishing his significant findings and opinions in reports on various 'Tours' that he had made. His books had much influence on practical farming. He was also instrumental in introducing new grasses. Young's name will always be associated with that of Sir John Sinclair, also a Fellow, who in 1793, after energetic advocacy, persuaded the House of Commons to found a Board of Agriculture. Sinclair was appointed President, and the no less enthusiastic and energetic Young as Secretary. Between them they greatly encouraged the wider application of the new methods resulting from the pioneer work of the great 'improvers'. Unfortunately, Young became blind in 1810 and Sinclair retired from the Board in 1813, having made, by his impetuosity, some enemies. Partly as a result of these changes, and of fiscal difficulties connected with the Napoleonic wars, the Board lost its Parliamentary grant and was dissolved in 1822.

Despite the farming depression of the late 1820's and early 1830's, agricultural science continued to develop, slowly at home and more rapidly abroad. Liebig, a Foreign Fellow of the Society, was, together with his pupils, experimenting in Giessen on plant nutrition, and in 1840, stimulated by the newly-found British Association for the Advancement of Science (whose early membership contained many active Fellows) clearly enunciated the tenets regarding the relation between soil constituents and plant nutrition which put agricultural chemistry on a firm basis. In 1834 Lawes, shortly to be joined by Gilbert, both eventually elected to the Royal Society, were beginning the long series of 'direct experiments in the field' at Rothamsted. These experiments put the relationship between soil constituents, soil fertility and plant growth in an ever clearer light. Their feeding trials with farm animals provided new information on the nutritional value and relationships of the main feed constituents, showing for example that carbohydrate in the diet was one of the main sources of deposited fat in the animal.

It is of more than chronological interest that the 'English Agricultural Society' was established at almost the same time that the Rothamsted partnership was getting under way. In 1837 Earl Spencer, a Fellow of the Royal Society and the driving force behind the English Agricultural Society, had said that 'the application of science to practice was not yet made by the English farmer'. In view of the developments in English (and Scottish) farming during the previous 60—70 years, this entirely negative statement was exaggerated, but when in 1840, the new Society was incorporated as the Royal Agricultural Society of England, with Queen Victoria as its Patron, it wisely adopted the motto 'Practice with Science'. Throughout its history of 160 years, this Society has endeavoured to live up to this motto. Amongst its earlier members were a number of F.R.S. and there can hardly have been a period without common membership, and mutual assistance in the pursuit of new knowledge, between the two societies.

The R.A.S.E. in 1843 appointed Lyon Playfair (a Fellow of the Royal Society) as Honorary Consulting Chemist. He was succeeded by J. T. Way, who was the first Professor of Agricultural Chemistry at the Royal Agricultural College at Cirencester. A keen research worker, Way worked for several years on the absorption

of inorganic fertilizers by the soil constituents. Way was succeeded in 1857 by Augustus Voelcker, a friend of Gilbert's who had been studying in Germany under Wohler and Liebig. Voelcker was elected to the Royal Society in 1870. He developed accurate methods for the analysis of foodstuffs, fertilizers and agricultural products, collaborated in a number of the Rothamsted researches (particularly in the planning of the well-known Woburn experiments on the long-range effects of fertilizing agents on the cultivation of wheat and barley), wrote several original papers on soil chemistry, and trained in his laboratory a number of agricultural analysts of distinction.

Of outstanding importance in relation to the advances that have been made in the present century in agricultural science and practice was the work of a Fellow, Sir Daniel Hall. Hall, who was principal of the Wye Agricultural College until 1902, was convinced that during the latter decades of the nineteenth century, British farming had suffered both from a slowing-down in the application of existing knowledge, and from inadequate facilities for basic research in agricultural science. The work at Rothamsted had lost its momentum as the original partners aged. Lawes had died at the age of 85 in 1900, and Gilbert in the following year, and it was not surprising that after Hall was appointed to the Directorship of Rothamsted in 1902 he set himself to reanimate the experimental work, modernize the research accommodation and widen the scope of the station. This had been largely chemical; Hall encouraged also the study of soil bacteriology and of the botanical and physiological aspects of plant growth.

After he had been nine years at Rothamsted, a still more extensive opportunity for increasing the facilities for agricultural research was presented to him. This followed the setting up, in 1911, of the £2,500,000 Development Fund, Hall being appointed one of the first Commissioners. One of the main purposes of this Fund was to extend research and education in agriculture, and Hall embraced with enthusiasm the opportunity of applying his knowledge of the needs of agriculture both to the development of a national scheme for agricultural research and also to improve the sketchy organization then existing for 'carrying science to the farmer'. It was decided by the Commissioners at Hall's prompting that a number of agricultural research institutes 'each charged with the fundamental research dealing with one particular branch of the subject' should be established. Several such institutes to deal with research on dairy farming and dairying, on grassland, on animal nutrition, on plant breeding, on horticulture, etc., nearly all of them in close association with a University or other senior teaching and research centre, were set up by the Commissioners during the next very few years and financed from the Fund. Also, to ensure that science could in fact be carried to the farmer, an agricultural organizer, to keep in direct touch both with improvements in agricultural practice and with the farmers, was appointed to each county, and, at eight Universities (or senior teaching and research) centres, a group of specialist agricultural advisory officers (many of whom were part-time members of the University staff) were placed. *Ad hoc* farming problems that called for specialist knowledge of agricultural chemistry, soil science, entomology, mycology, bacteriology, economics, or veterinary science, which were sent to the advisory officer either by the county organizer or from some other source, could now be tackled with some hope of success. In planning this organization, Sir Thomas Middleton, also a Fellow, played a large part. He later became the first Vice-Chairman of the Agricultural Research Council.

Another of the Development Commissioners, Prof. T. B. Wood, at one time Professor of Agriculture in the University of Cambridge, and also a Fellow, made, with his colleagues, substantial, quantitative contributions both to the chemistry of crop production and to the utilization of the produce of the soil for the feeding of animals. His work forms the basis of present-day methods for the computation of rations for live stock.

The agricultural research and farm advisory system in Great Britain which was the result of the joint effort by Hall and Middleton backed by a Commission which had both money and imagination, has been largely responsible for the steady improvement in British farming methods which has taken place, despite economic ups and downs, during the last half century. Outstanding discoveries have been made in the agricultural research institutes founded by the Commission. Many of these findings have been successfully applied in the industry which now provides about half of the food eaten in these islands. These research institutes have had their work co-ordinated since 1923 by the Agricultural Research Council, each of the distinguished secretaries of which has been a Fellow. This Council has had, from the beginning, a substantial number of Fellows in its membership.

Important findings on the effect and function of trace elements in plants and animals, on endocrinology and reproduction, on bacteriology and virology in relation to animal and plant diseases, on genetics and the breeding of plants and animals, on nutrition and the function of vitamins and minerals, on the control of pests and weeds, have been made by many Fellows alive today. As regards farming practice, at least four living Fellows, all retired directors of agricultural research stations have, through their own work and that of their colleagues in the institutes they directed, instilled new vigour into the improvement of plant and animal husbandry.

A brief mention may be made of past Fellows' work in the vitamin field. These dietary accessory factors are of no less importance to the progress of animal husbandry than to the betterment of human nutrition; in many of the proprietary diets sold nowadays to specialist farmers to meet the requirements of various species of farm animals at different stages of growth or of production, feedingstuffs manufacturers make competent use of up-to-date knowledge of the vitamins required. Relative to the long history of the Society,

the study of these highly active substances is of recent date. Much of our present knowledge has been obtained by the researches of Fellows who are still alive.

In this field, the pioneer investigations of Sir F. G. Hopkins, who became President of the Society in 1930, were of major and fundamental significance. He showed clearly in 1906 that a minute deficiency in an animal's diet could cause a disease, a conception that had to overcome the traditional view that disease was always the result of a positive factor such as an infection by micro-organisms. He examined the physical and chemical properties of some of the dietary accessory factors he had discovered, and whose absence was responsible for different types of dystrophy. These effects included not only inability to grow followed by more or less rapid decline (caused by the absence of one fat-soluble factor) but also what was at that time a common disease in young children and by no means unknown in other animals—rickets, caused by the absence of another fat-soluble factor. That cod liver oil would prevent and cure rickets was an observation of long standing, but it was mainly the work of Hopkins and his school that showed why this was so. Sir Edward Mellanby, Dr. Otto Rosenheim, both Fellows, and their colleagues at home and abroad, were eventually able to place on an intelligible basis the, at first, very puzzling relation between rickets, irradiation by ultra-violet light, distortion of the mineral content of the diet, and the vitamins concerned. Other Fellows contributed significantly to these findings. The growth factor, vitamin A, discovered by Hopkins in milk fat and present in other animal products (the absence of which from the diet also leads to eye disease) was examined in detail by Sir J. C. Drummond and by Sir Ian Heilbron, both Fellows. Its connection with the plant pigment β-carotene was established and its chemical structure verified. Mellanby demonstrated the association between acute vitamin A deficiency in the diet and lesions of the nervous system.

Drummond and his colleagues in the 1930's made substantial contributions towards the separation and elucidation of the chemical identity of a fat-soluble factor, first discovered by American workers, in vegetables and in a more concentrated form in vegetable oils, and called by them vitamin E, without which rats, mice and other animals became infertile. It was later shown by other workers that three tocopherols of slightly differing composition all had vitamin E activity but differed in their biological potency.

That fresh fruits and vegetables, as well as preserved lemon and lime juice, would prevent and cure scurvy was an observation of long standing, dating back to the 1700s. Captain Cook, the explorer, also a Fellow and an observant sailor, published in the Phil. Trans. of the Society in 1776, the successful methods he had used to preserve the health of his ships' companies during long voyages by the use as frequently as possible of fresh animal products and fresh vegetables, and the daily consumption of sourcrout and wort. It was only in 1933 that the chemical identity of the protective agent—ascorbic acid—was established, by a Fellow, Sir W. N. Haworth, with another Fellow still alive, and their colleagues, practically simultaneously with three groups of research workers in laboratories overseas.

Since Hopkin's days, all the vitamins referred to, and also those in the water-soluble B group, have been studied by Fellows still alive, and, as a result of their researches, immense progress has been made in our knowledge of the chemical constitution and mode of biological action of these astonishingly potent substances.

Summary

The relationship of the Royal Society, during its 300 years' history, to agricultural progress seems to have passed through the following phases. In the very early years of the Society, when a substantial proportion of its membership had immediate interest in farming, there was a keen endeavour to collect and collate reliable information on the most successful husbandry practice, with the object of deriving principles upon which advice to intelligent agriculturists could be based. This phase was followed by one in which there was additional emphasis by Fellows on the study of the then embryonic sciences basic to agricultural improvement—botany, zoology, chemistry, physiology, soil science—together with noteworthy advances, some of them initiated and carried out by Fellows, in experimental husbandry. During the next hundred years of the Society's existence up to about 1920, partly as a result of the change in its organization which occurred in 1838, the amount of attention given to the more practical agricultural problems by Fellows, though considerable, was proportionately less than that given to the basic sciences of physics, chemistry, geology, botany, zoology and physiology. During this period the number of those elected to the Society who were mainly interested in the application of scientific knowledge to agricultural practice was small, though there were a few famous names amongst them. With the revivifying of agricultural research, following the activities of the Development Commission of 1909, the number of Fellows engaged in applying science to agriculture has increased, with notable effects on farming practice in Britain. Many of these Fellows are still with us.

A standing Committee for Agricultural Science was established by the Society in 1945.

LABORATORY APPARATUS AND MATERIALS EXHIBITION

The August issue of *Laboratory Practice* will contain most of the lectures presented during the recent successful Laboratory Apparatus and Materials Exhibition, together with an illustrated review of the exhibits on show at the new Horticultural Hall.

News from the British Association of Chemists

The Organization of Professional Men

Readers of this page will recall that the B.A.C. has pointed out from time to time during the last two years, what has actually been achieved by professional men in Western Europe by way of protecting and furthering their economic interests. They have been able to do this because they have combined together, both nationally and internationally and the B.A.C. has given a lead to those in this country by becoming associated with them.

It is very gratifying to note that further exploratory steps have now been taken in this country. The British Medical Association held a meeting in London in March to which representatives of many professional associations—among them the B.A.C.—were invited.

The Chair was taken by the Chairman of the Council of B.M.A., who explained that the meeting, being purely exploratory, no minutes would be taken and no formal resolutions would be put. In the opening address to the meeting, a member of the B.M.A., stated that in the opinion of many of his colleagues, it was becoming very desirable that there should be brought into existence some permanent organization able to represent the interests of professional men and women generally and it should be in a position to speak for them when required, for example in Parliamentary matters, in negotiations with the Government, as employers, and in other matters affecting status and salaries. The organization might be in the form of a confederation with a council analogous to the T.U.C., or, alternatively, some looser form of association might be adopted. Whatever form of organization may be decided on, it must be non-political. The object of the meeting was to explore the possibility of forming such an organization.

An animated discussion then ensued to which representatives of many professional associations contributed and revealed various shades of opinion on the proposals.

The majority of the speakers were in favour of some form of confederation or similar joint professional organization, but a few expressed the fear that, instead of being consultative, the organization might develop into a pressure group. As the discussion progressed it became apparent that the Societies least in favour of the proposal were those having a high proportion of self-employed members, such as barristers, accountants and solicitors. It was generally agreed that, if progress is to be made, further discussion will be required on:

(*a*) the constitution of the organization to be set up in the first instance, and

(*b*) the types of professional bodies which are to be eligible for membership of such an organization.

Subsequently, as mentioned on this page last month, the B.A.C. invited representatives of the same bodies to meet members of the international professional association who were visiting London.

It is hoped, that from these tentative initial steps, there may emerge in this country a body which can not only protect the interests of its own members but which could have a beneficial influence generally by reason of its having no political affiliations.

THE HINCHLEY MEDAL

The Association's Hinchley Medal for 1958, which had been awarded to Dr. C. J. T. Cronshaw, was actually presented to him on May 11, 1960 at a private ceremony at Dr. Cronshaw's home. The award was made in appreciation of his great services to the chemical industry while head of the Dyestuffs Division of Imperial Chemical Industries Ltd. Dr. Cronshaw has been a member of the B.A.C. since 1934.

The presentation was made by the President of the B.A.C., Mr. John Wilson, C.B.E., M.C., M.Sc., F.R.I.C., F.I.R.I., who was accompanied by Mr. R. J. Mollard, a Vice-President, and Mr. J. Rickman, Chairman of the Manchester Section of the B.A.C.

The Hinchley Medal for 1959 has been awarded to Mr. L. E. Puddefoot, B.Sc., and it nas been arranged that the presentation shall be made in the autumn of this year. On this occasion Mr. Puddefoot will deliver the Hinchley Memorial Address.

WITHOUT COMMENT

Some Salary Discrepancies

The B.A.C. salary scales perform a useful purpose in establishing reasonable minimum levels for both qualified chemists and assistant grades. What a salary scale cannot do, however, is to ensure that in any one firm there are no serious discrepancies between the salaries paid to chemists and assistants and the various levels of so-called 'administrative' and commercial staff.

A smart laboratory assistant, to avoid having to spend his spare time in study, can often obtain a post as a junior 'rep.', where as often as not his salary with commission, will be well into four figures, not to speak of 'perks', and often above that of qualified laboratory personnel, on whose work his income depends.

It has been estimated that there is a factor of no less than two and a half between the scales for chemists and assistants, and the actual emoluments paid to the corresponding grades of sales staff. Would any reader like to challenge this?

'Me-Too-Ism'

A United States chemist, commenting on certain elements in his own organization, criticized them for adopting a policy, which he described with a delightful translantic touch as 'me-too ism'—in other words waiting until someone else has placed a new product on the market and then straining the resources of their research sections to produce something similar.

Research is the life blood of the chemical industry, and the fact that the chemical industry is one of the fastest expanding ones in the country may produce an apparent justification of 'me-too-ism'. However, the fact that a large amount of the research potential in this country is devoted to the art of sample matching is not a good omen, when competition from abroad is becoming ever more fierce. 'Me-too-ism', a policy of a salesman dominated industry, causes intense frustration among research-minded chemists, and may be responsible for the fact that a large number are seeking their fortune in the U.S.A., where the shape of things to come is considered equally with immediate requirements.

OBITUARY

The decease of the following members is recorded with regret:

J. R. Hannay. Elected Member 1918/19.
E. Hardman. Elected Member 1918/19.
H. E. E. Honey. Elected Member 1927.
W. H. Morrow. Elected Member 1932.
J. W. Reid. Elected Member 1927.
G. E. Waller. Elected Member 1953.

LIFE MEMBERS

The following have been elected Life Members of the Association:

F. Higson. Elected Member 1918/19.
R. S. Rack. Elected Member 1925.
T. C. Robinson. Elected Member 1937.
S. Smith. Elected Member 1927.

News from the Sections

Liverpool

The following officers and committee were elected for 1960/61:

Officers:

Chairman	H. L. Haigh
Vice-Chairman	G. H. Martin and H. Clarke
Hon. Secretary	K. S. Ford
Hon. Treasurer	G. Ikin
Hon. Recorder	A. R. Jones
Education Officer	R. J. Mollard.

Committee:

Messrs. C. J. H. Wylie, W. Quirk, B. Stockton, T. E. Fawcett, H. P. Minton, K. Thompson, T. Q. Matthews, G. A. Dunn, J. S. Frodsham and W. S. Reid.

LABORATORY EQUIPMENT & APPLIANCES

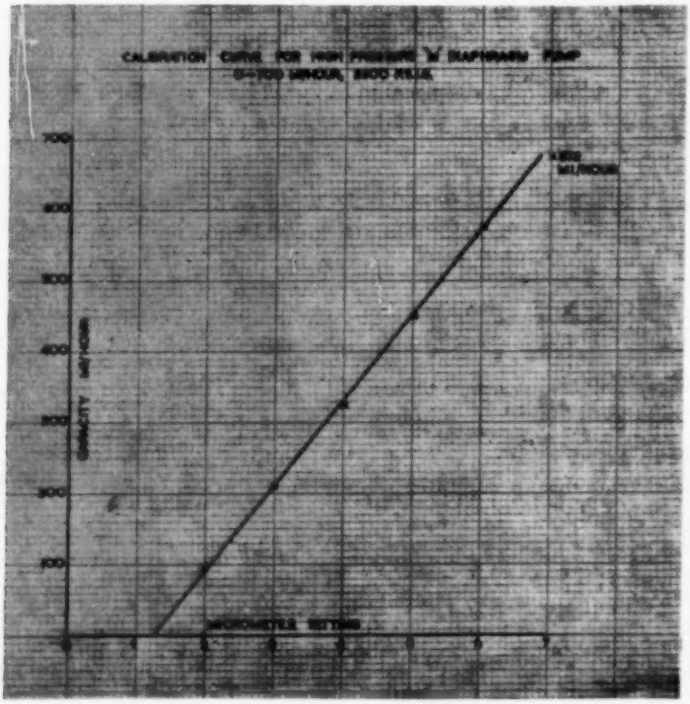
High Pressure Metering Pump

In view of the ever increasing demand for accurate metering pumps of very small capacity but of a high degree of metering accuracy and without glands on the pumping side, a diaphragm pump has been developed with the characteristics which meet these requirements.

The fundamental mechanism of the D.C.L. 'M' pump has been built into a high pressure diaphragm head unit and the calibration curve shown indicates the extraordinarily high accuracy which is obtainable with a pump tested at 2,500 p.s.i.g. with the very small maximum capacity of 700 ml./hr. At this pressure, the compressibility of the hydraulic fluid which operates the diaphragm and the compressibility of the fluid being pumped are significant, but calculable, and when these factors are taken into account the necessary allowance can be made by choosing the appropriate micrometer setting for the required delivery capacity and the characteristic straight line calibration of range of D.C.L. metering pumps is retained.

The price is dependent to some extent upon the materials of construction and pressure-capacity requirements. The cost of a unit with stainless steel head, for example is approximately £160.

(Manufacturers: The Distillers Co., Ltd. Great Burgh, Epsom, Surrey.)



Portable Barrel Deburring and Finishing Machine

An interesting new Almco Supersheen deburring and finishing machine, the Super Mite DBM-10, has been designed especially for research departments, laboratories and for processing small quantities of parts. Portable and compact, the machine can also be used for test runs on small components, thus saving the use of larger and more expensive machines in the production line.

The model is inexpensive and will deburr and finish parts to close tolerances in a fraction of the time and cost needed for carrying out these operations by hand.

Features of the machine are that it is easily portable and can be carried by one man. The barrel, which measures 12 in. in diameter by 8 in. wide, has a capacity of ½ cu. ft.; it can be easily lifted from the compact and rigid base and revolves at an infinitely variable speed of between 19 and 38 r.p.m. A quick opening door of the swivel-bar type is fitted to the barrel.

Speed can be varied easily by a hand wheel fitted to the frame. Drive is provided by a ¼ h.p. 220 volt single phase motor through a fully guarded pulley. An 8 ft. length of flex is provided with each machine.

The rubber lined barrel revolves on hard rubber rollers which are hard wearing and quiet in operation.

(Manufacturers: Almco Supersheen of Great Britain Ltd., Bury Mead Works, Hitchin, Herts.)

CATALOGUES, BROCHURES & LEAFLETS

Received from Manufacturers

Atomic Terms.—The U.K. Atomic Energy Authority have published a useful glossary of atomic terms which has been prepared by the Technical Writers Section of the Public Relations Branch of the Authority. (H.M.S.O. price 3s. 6d.)

Laboratory Heating Equipment.—A very comprehensive catalogue has been published by Electrothermal Engineering Ltd., of 270 Neville Road, London, E.7. Full technical information and prices of the company's wide range of laboratory apparatus, scientific instruments and surface heaters are included.

Incidental information

No.13

Items of interest from our laboratory notebooks

Most analysts know about 1:10-phenanthroline and many use it for iron determinations. Not so many people seem to know that **4:7-diphenyl-1:10-phenanthroline** is twice as sensitive as 1:10-phenanthroline in the colorimetric determination of iron. There are several papers on the subject but the latest is *Analyst*, 1958, **83**, 80. The reagent is also called **Bathophenanthroline**, and we make it.

Then again, the substitution of methyl groups in the 2:9 positions has the interesting effect of making the reagent insensitive to iron and we then have a selective and sensitive reagent for copper (see *Anal. Chem.*, 1956, **28**, 1158). Hopkin & Williams make **2:9-dimethyl-1:10-phenanthroline** (sometimes called **Neo-cuproin**).

One does not think of sulphate as a radical one can determine absorptiometrically, but this is now possible for low concentrations. **Barium chloranilate** is the reagent and there are two papers on the subject — *Anal. Chem.*, 1957, **29**, 281 and *Anal. Chem.*, 1958, **30**, 202. Hopkin & Williams make it.

Hopkin & Williams Ltd. were also early off the mark with supplies of the remarkable new colour-producing reagent for fluoride ions, **3-aminomethylalizarin-NN-diacetic acid**, described by Belcher, Leonard and West (*Talanta*, 1959, **2**, 92). This important reagent is already available from stock.

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NEWS

General

Kaduna's New Laboratory

A milestone in the Northern Nigerian Government's efforts to provide a thoroughly up-to-date health service is the new Pathology Laboratory which was opened recently at Kaduna, the capital.

It carries out microscopic examination of blood diseases, of diseased tissues which may be affected by cancer, ulcers, abscesses and the like; identifies infective organisms such as those which cause leprosy, tuberculosis, dysentery, and enteric fevers, and parasites by which humans may be infested, such as amoebae, worms (and their eggs) and eggs of bilharzia.

The laboratory also undertakes the study of pathogenic alteration in the chemistry of body fluids, such as estimation of the sugar content in diabetics' blood, and the investigation of blood serum to check for reactions brought about by syphilis, typhoid and typhus.

Much of the work aids the well-being of expectant mothers—an average of 100 attend the ante-natal clinic in the laboratory for blood tests every week. Northern Nigerian wives now appreciate that this is the only way to reduce infantile mortality.

Indigenous staff who will eventually man similar laboratories elsewhere in the country are also trained here, and the attractions of a career in the pathology service are now more widely appreciated.

New Research Laboratory for Metropolitan Leather Co., Ltd.

Parkinson Cowan (Metropolitan Leather Company Limited Division) are shortly to open a new gas meter diaphragm testing and research laboratory at their Great Harwood, Lancs., factory.

Included in the Metropolitan Leather research programme are continued investigations into the use of polymer as diaphragm material—an activity first undertaken by the company as long ago as 1952.

Equipment installed in the laboratory has been specially designed to test new products so thoroughly that the need for subsequent field trials is virtually eliminated.

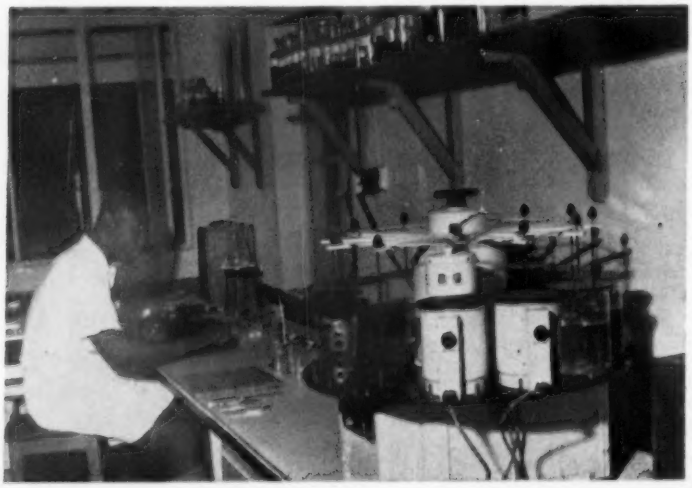
Cambridge House

During the evenings of May 25 and May 26, a total of more than 100 guests attended receptions held at Cambridge House (the new name for the Head Office and showrooms of the Cambridge Instrument Company at 13 Grosvenor Place, London).

The receptions, held in the showroom and the new boardroom were to celebrate the internal rebuilding and redecorating being carried out to modernize the company's recently enlarged premises. These will accommodate the staff necessary to deal with the additional business resulting from the present expansion of research and production facilities.

B.S.I.R.A. Extend Workshops and Laboratories

Work has now started on the erection of a new 7,300 sq. ft. building at the headquarters of the British Scientific Instrument Research Association at Chislehurst, Kent. The building which will comprise new workshops and mechanical laboratories should be completed in the late autumn. The new laboratories will enable the Association to extend its activities in the Mechanical Engineering field, while in the workshops provision has been made to accommodate more specialized equipment and precision machine tools thereby improving the workshop facilities available both to the laboratories and to member firms in the Association.



Sections of diseased tissue are cut in Kaduna's new pathology laboratory.

Manufacturers' News

Griffin & George acquire R. & J. Beck

Griffin & George, Ltd., have purchased the whole share capital of R. & J. Beck, Ltd. The latter company operate two works, at Watford and Kentish Town, and have offices and a showroom at Mortimer Street, London, W.1.

It is the intention of Griffin & George, Ltd., to retain the individuality of Beck's as a separate entity, and the name of the business will remain unchanged.

The present Board, consisting of Messrs. C. J. Beck, S. Borthwick, G. E. Fowler and H. W. Morgan, will remain in office and be joined, in due course, by Messrs. M. Lyth, H. C. Mayer, R. C. Palmer and F. A. Renn as additional Directors representing Griffin & George, Ltd.

R. & J. Beck, Ltd., manufactured the new 3-D image microscope, designed by a team led by Mr. Richard Gregory, at the Cambridge University Psychological Laboratory. (See *Laboratory Practice*, **9**, 386). The microscope is proving useful in the examination of living cells and thick sections of suitably strained brain tissue to see how the brain cells are related to each other.

Publications

Survey of British Transistors

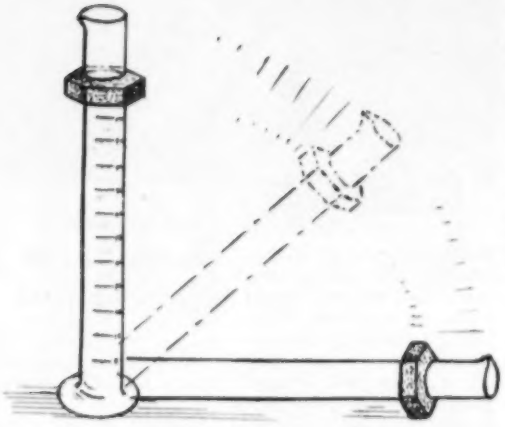
The essential technical characteristics of 963 different semiconductor devices now available from British manufacturers are given in tabular form in *British Semiconductor Guide*, a new publication just issued by Heywood & Co. (5s.)

They are presented in three main groups: transistors, diodes and rectifiers, and photosensitive devices, together with important technical details and sources of supply.

Enzymes

A new booklet on Enzymes has been compiled by Globe Products (Accrington) Ltd., of Accrington, Lancs., in conjunction with their associates Novo Industri A/S, Copenhagen. This booklet (75 pages) not only gives information, illustrated by graphs, on the activity and stability of many types of enzymes under various pH values and temperatures, but also details of recognized methods of enzyme evaluations.

Non-roll cylinder protectors



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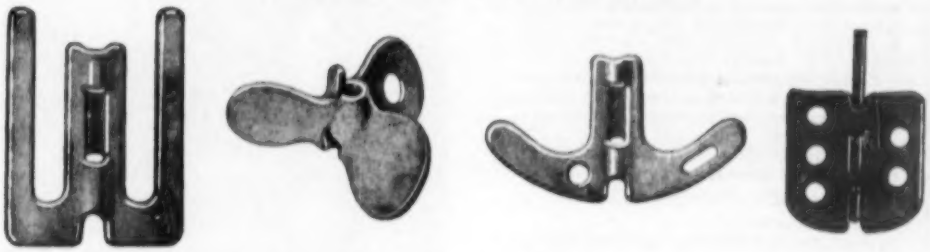

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US PAT NO 2, 655, 280

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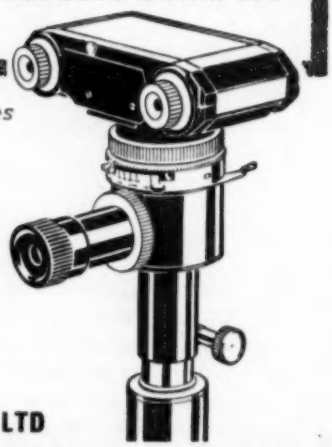

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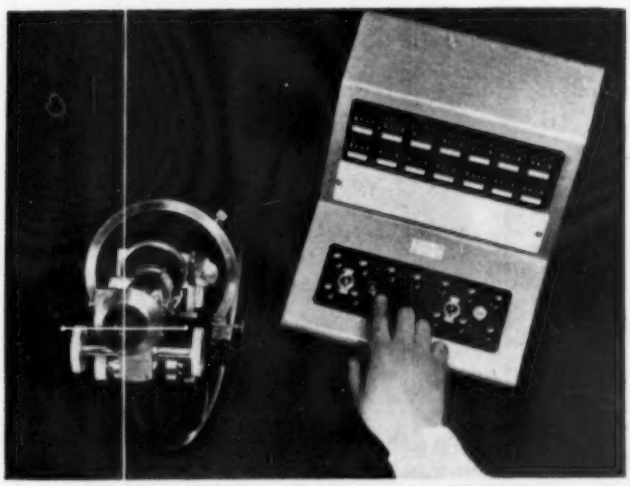

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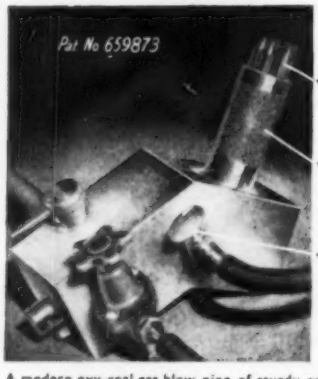

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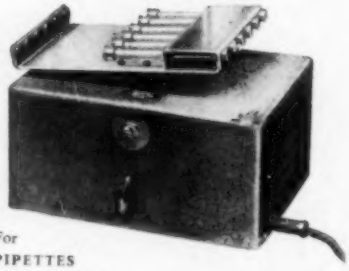

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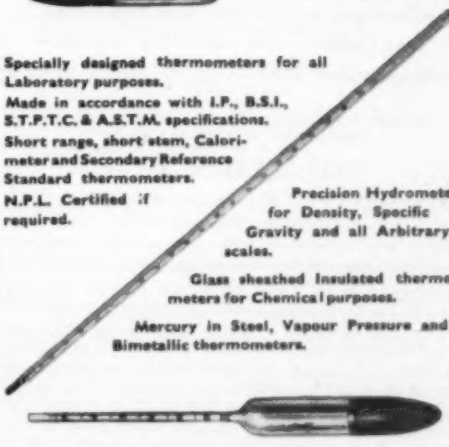

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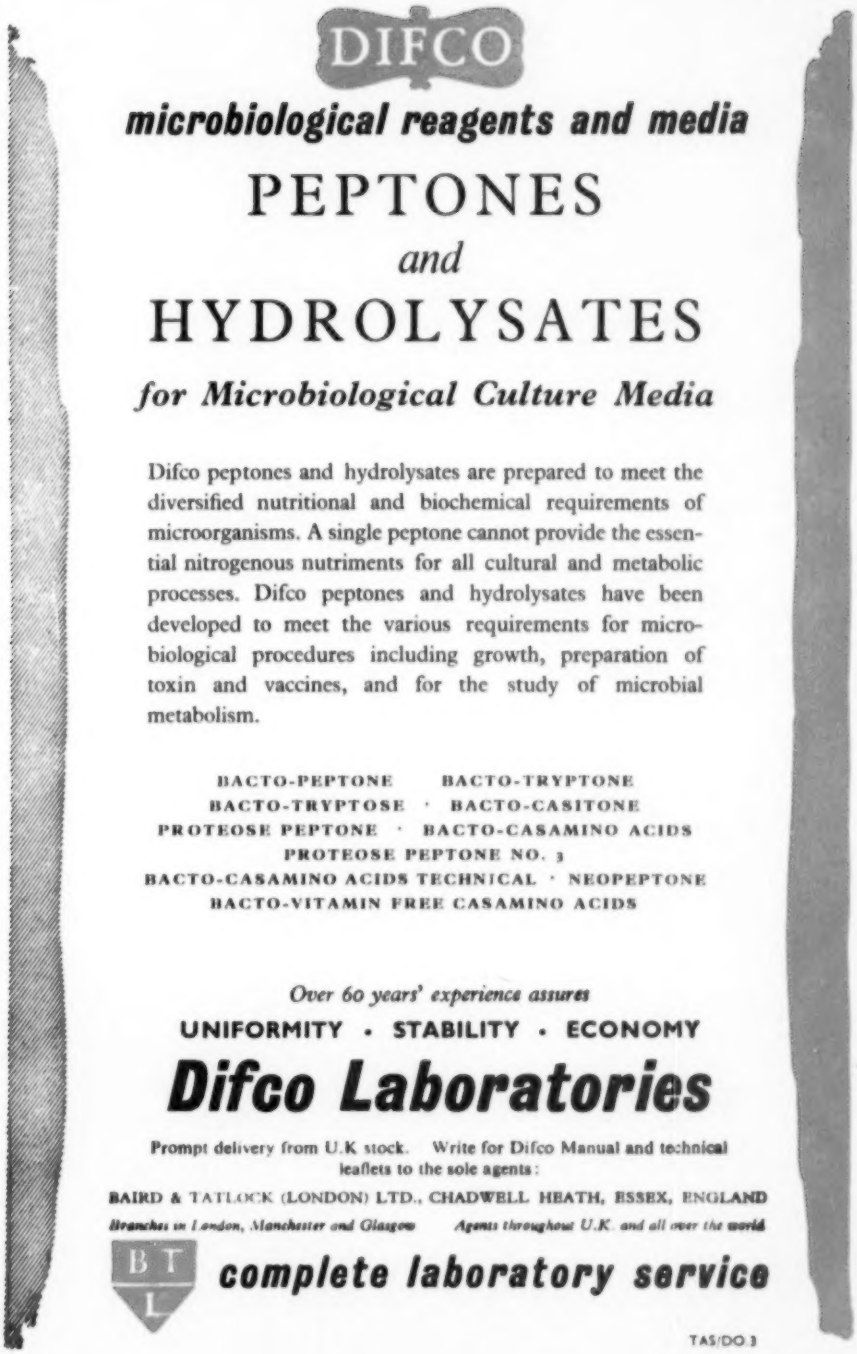

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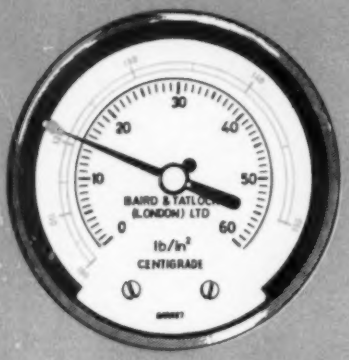

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